Building Urban Resilience

Assessing Urban and Peri-urban Agriculture in Dakar, Senegal

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Building Urban Resilience

Assessing Urban and Peri-urban Agriculture in Dakar, Senegal

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Preface

Food production in and around cities is an integral part of the urban fabric in much of the developing world. In these regions, urban and peri-urban agriculture (UPA) plays an important role in diversifying urban diets and providing environmental services in urban and peri-urban areas. As such, there is growing interest in UPA as a strategic component of urban resilience and climate change adaptation planning. However, advocacy for UPA in this capacity is outpacing the body of evidence regarding important stressors and drivers that act on UPA. Such knowledge is especially critical in the developing world where urban areas are experiencing rapid growth and transformation. In these regions, UPA is facing intensifying pressures from urban encroachment, waste disposal, pollution, and climate change that may undermine the sector's long-term viability.

The need to better understand these critical sustainability dimensions provided the impetus for city-level knowledge assessments of UPA, whose main findings are contained in nine underlying assessment reports including this one. The assessed cities were Dakar (Senegal), Tamale (Ghana), Ibadan (Nigeria), Dar es Salaam (Tanzania), Kampala (Uganda), Addis Ababa (Ethiopia), Dhaka (Bangladesh), Kathmandu (Nepal) and Chennai (India). All of the reports and the synthesis report can be found at *http://start.org/programs/upa*. The assessments were conducted in 2012, with initial stakeholder engagement beginning in 2011. The assessments were led by city-based teams, the composition of which varied, with some of the teams being comprised predominately of researchers and other teams comprising of a mix of researchers, city officials and urban NGO representatives.

The assessments seek to better understand the changing nature of UPA systems, and the critical interactions at the land-water-climate nexus that influence resilience of UPA in rapidly growing developing-country cities. The audience for these assessments includes national and city-level policymakers, sectoral experts and city planners, the research community, and non-governmental organizations (NGOs) that interface with urban farmers and other actors within the broader UPA sector.

The UPA assessments are part of a larger project on strengthening understanding of critical links between climate change and development planning in West Africa, East Africa and South Asia. The premise for the project is that progress towards undertaking effective action to address climate change risks in these regions is hindered by low levels of awareness of global climate change, lack of understanding of the findings of the Intergovernmental Panel on Climate Change (IPCC) and other sources of scientific information, lack of location and sector specific knowledge, and the need for strengthening capacities to undertake integrated assessments that support decision making. This multi-year project has been a collaborative effort between the World Meteorological Organization (WMO), the United Nations Environment Programme (UNEP), START, the University of Ghana, the University of Dar es Salaam, and the Bangladesh Centre for Advanced Studies (BCAS).

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We would like to thank the different individuals and institutions who in one way or another contributed to the execution of the larger European Commission-led project. In particular, the successful implementation and completion of the project, and the subsequent knowledge assessments were made possible due to the close cooperation and commitment of the International START Secretariat; the United Nations Environment Programme (UNEP) represented by the Division of Early Warning and Assessments and the Office of the Chief Scientist; the World Meteorological Organization (WMO), the University of Ghana, the University of Dar es Salaam, and the Bangladesh Centre for Advanced Studies (BCAS). Several colleagues across these organizations rendered valuable insight, expert advice, guidance and encouragement during this 4-year endeavor. We would especially like to recognize the efforts and support of Ghassem Asrar, Hassan Virji, Katie Dietrich, Clark Seipt, Chris Gordon, Pius Yanda, Atiq Rahman, Chipo Plaxedes Mubaya, Adelina Mensah, Elaine Tweneboah, Abu Syed, Salif Diop, Audrey Ringler, Jennifer Odallo, Peter Gilruth and Joseph Alcamo as well as Jon Padgham and Jason Jabbour, the project managers and editors of this series.

The overall project and the associated UPA assessments were made possible in large part thanks to funding provided by the European Commission (through project ENV/2008/149690 '*Understanding the Findings of the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report "Climate Change 2007"—Integrating Climate Change Adaptation and Mitigation in Development Planning*'), as well as by the United Nations Environment Programme (UNEP), and the Global Climate Change Programme at the US Agency for International Development (USAID). The editors of this series wish to thank these organizations for their financial support.

In addition to the numerous authors listed in each of the separate reports, we are grateful to the following people for providing useful insights and feedback during the early conception of the knowledge assessment, and helpful review comments on the various manuscripts: Rafael Tuts, Anna Skibevaag, Stephen Twomlow, Elizabeth Migongo-Bake, Trang Nguyen, Volodymyr Demkine, Jane Battersby, Marielle Dubbeling, Anna Kontorov, Richard Munang, Jesica Andrews, Fatoumata Keita-Ouane, Jacqueline McGlade, Keith Alverson, Stuart Crane, Martina Otto, Robert Yennah, Beverly McIntyre, and Tom Downing. We would also like to express our sincere appreciation for the generous support of colleagues at the University of Cape Town's *Climate* Systems Analysis Group who with the climate projections for six African cities.

Acronyms and abbreviations

ANSD	Agence Nationale de Statistique et de la Démographie (National Agency of Statistics and Demography)
ATADEN	d'assistance technique au développement économique des *Niayes* (Technical Assistance for *Niayes* planning and Economic Development)
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement (French Agricultural Research Centre for International Development)
CMIP5	Coupled Model Intercomparison Project Phase 5
CRDI	Centre de recherches pour le développement international
DDT	Dichlorodiphenyltrichloroethane
EDNA – RUF	Environnement développement action—Relais pour le Développement Urbain Populaire
FAO	Food and Agriculture Organization of the United Nations
GCCP	Global Climate Change Partnership of the United Nations
GFDRR	Global Facility for Disaster Reduction and Recovery
GHG	Greenhouse gas
GIE	Groupement d'Intérêt Economique
GRET	Group of Research and Technological Exchanges
IAGU	Institut Africain de Gestion Urbaine (African Institute for Urban Management)
ICMSF	International Commission on Microbiological Specifications for Foods
IDRC	Institute of Research and Development (of Canada)
IFAN	l'Institut Fondamental d'Afrique Noire
IPCC	Intergovernmental Panel on Climate Change
IRD	L'Institut de recherche pour le développement
ISRA	Institut sénégalais de recherche agricole
NGOs	Non-governmental organizations
NRC	National Research Council
ONAS	Office National de l'Assainissement du Sénégal (National Office of Urban Sanitation in Senegal)
PASDUNE	Programme d'Action pour la Sauvegarde et le Développement Urbain des *Niayes* et zones vertes de Dakar
PDU	Plan Directeur d'Urbanisme (Urban Master Plan)
PNAT	Plan national d'aménagement du territoire
POP	Persistent organic pollutants
PPMP	Planning and preservation master plan
RCP	Representative Concentration Pathway
RegCM3	Regional climate model, version 3
RUAF	Resource Centres on Urban Agriculture and Food Security
START	Global change SysTem for Analysis, Research, and Training
UCAD	Universite Cheikh Anta Diop
UNEP	United Nations Environment Programme
UPA	Urban and peri-urban agriculture
WHO	World Health Organization
WWTL	Waste Water Treatment Laboratory

Contents

Executive summary

This report presents the findings of a knowledge assessment on urban and peri-urban agriculture (UPA) for the city of Dakar, Senegal, that was conducted in 2012. It examines the state of UPA in the city through the lens of intensifying urban pressures and increasing climate risks with the objective of identifying how these and other drivers potentially interact to affect the long-term sustainability of UPA, and what response options are needed to address existing and emerging challenges. The assessment is intended to:

1) describe the dominant characteristics of urban and peri-urban agriculture, and identify key knowledge gaps in these UPA systems;
2) explore the array of stressors that contribute to vulnerability of UPA systems to climatic and other environmental changes; and
3) identify critical areas for strengthening policies and institutional capacities that contribute to sustaining the UPA sector within the larger context of resilient cities and food systems.

Urban and peri-urban agriculture (UPA) in the Dakar region is well developed and contributes significantly to the city and region's food basket, and to the economic vitality of the urban food system. Extensive areas of vegetable production primarily occur in the *Niayes*, a geological depression with a high water table that runs through the region. UPA is linked to domestic and overseas markets, with production systems encompassing a range of small and large-holding producers that provide seasonal employment for urban and temporary rural migrants. Despite UPA's economic significance, the sector is subject to many constraints, particularly with respect to the availability of appropriate land, uncertainty about land ownership, inadequate access to quality irrigation water, inadequate policy protection and weak investment. These factors undermine the sustainability of the sector and contribute to health and environmental hazards, such as those linked to use of untreated wastewater for vegetable production.

In particular, the lack of suitable land and water presents a major challenge to the long-term sustainability of UPA in Dakar. With the reduction of urban agricultural space and a decline in the supply and quality of ground and surface water, more intensive technologies—irrigation networks, drip irrigation and trailer pumps, etc.—are becoming increasingly necessary, which could further drive up costs of production and reduce profitability. The current challenges associated with land and water resources will become increasingly acute as urbanization pressures and climate change intensify in the coming decades.

The emergence of an informal land market, combined with weak or non-existent enforcement of land-use regulations, drives urban/peri-urban land-use conversion in the Dakar region. While Senegal has developed an action plan for protecting the *Niayes*, non-compliance with zoning regulations, overlapping and ill-defined regulatory authority between state and local governments, and the strained coexistence of customary law with constitutional law undermine protection of agricultural lands in the Dakar region, and further marginalizes agricultural production activities.

Key findings

Urban encroachment threatens the long-term viability of UPA. Rapid urban growth in the Dakar Region exerts significant pressure on land and water resources. Dakar's population has more than tripled since the 1970s, with much of the resulting urban growth occurring at the expense of peri-urban farmland and in areas that have high hazard potential for inland flooding, coastal erosion and sea-level rise. Presently, only a part of the humid depressions of the *Niayes* inside the city of Dakar are not threatened with conversion away from its current agricultural use. The fact that agriculture is losing ground to real estate development is an outcome of ambiguous land and urban planning policies on the part of authorities, a disregard for rules, particularly city planning codes, and the uneasy cohabitation between customary law and constitutional law.

Risks associated with climate change, while currently not an important driver of UPA's sustainability, will become more prominent in the future. Over the past two decades Dakar has faced recurrent flooding problems, which are linked to the city's rapid urban growth and changing land-use patterns. Flood risks are likely to increase in the future given, the potential for increased frequency of high-intensity rainfall events associated with climate change in combination with land-use changes. Land around and within the *Niaye* depression is being rapidly converted from permeable surfaces, many of which supported agriculture, to impermeable surfaces to meet housing and other urban infrastructure needs. Sea-level rise presents an additional threat to the city's infrastructure and to the coastal lakes and agricultural areas of the low-lying *Niayes*, which are particularly at risk for saltwater intrusion. Given Dakar's peninsular location, the city is highly vulnerable to sea-level rise resulting from global warming. A sea-level rise of 0.5 m, well within the realm of likelihood for the second half of this century, could substantially worsen saltwater intrusion into the already stressed aquifers that provide water for Dakar, including to its large UPA sector.

In-depth assessments are needed to estimate the extent to which flood risks could increase with current and future pressures on land-use conversion in sensitive areas, such as in *Niayes* urban agricultural lands, and projections of changes in rainfall characteristics. A comprehensive assessment would take into account the changing nature of flood risks to UPA production.

Declining water quality and availability challenges the continued viability of Dakar's agriculture sector. UPA farmers across the Dakar Region are contending with decreasing freshwater quality and quantity, and they are facing uncertainty about future access to water for irrigation. The increasing demand for freshwater for non-agricultural uses combined with the potential for higher irrigation water demands under warmer and more variable conditions will place greater stress on water supplies and infrastructure that UPA farmers rely on for irrigation. On top of that, increased salinization of groundwater and soils from sea-level rise may further stress the water resource base needed to support the sustainability of Dakar's economically important horticultural sector. The high reliance on untreated wastewater by Dakar's UPA farmers presents significant health hazards to both producers and consumers of vegetables. Efforts to address this hazard by providing treated wastewater for irrigation have failed to move beyond an externally funded project phase.

Addressing threats to UPA's long-term sustainability requires strengthening the position of UPA in urban planning. A formal communication process is needed in order that policy makers and local authorities come to recognise UPA as a factor in urban development. Senegal has a policy framework for protecting the *Niayes* in the Dakar Region (PASDUNE) and other policy mechanisms that are conducive to the mainstreaming of urban agriculture in urban planning master plans that could help

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to meet policy goals related to urban agriculture. However, a lack of clear delimitation of functions and responsibilities between national government and local government authorities has resulted in poor enforcement of land-use planning regulations, which combined with a sharply increasing value of land for real estate development, has served to further marginalize agriculture in peri-urban areas.

As part of any effort to mainstream UPA into policy frameworks, there is a critical need to organize urban farmers under an umbrella organization that can work with municipalities to mainstream the horticultural zones of Dakar into town planning master plans or into the detailed urban plans of those areas that fall under the Government of Senegal's PASDUNE and ATADEN policy frameworks. Such an effort would contribute to securing legal recognition of the farming areas, which is important for the long-term sustainability of the sector, particularly for small-scale peri-urban farmers, most of whom acquire their land through customary rights and as such lack formal land title.

1 Introduction

Located on the Cap Vert Peninsula, the Dakar Region stretches over an area of 550 km². The region is bordered to the north, west and south by the Atlantic Ocean and to the east by the Thiès region, a position that offers very little space for expanding the urban boundary. Administratively, Dakar comprises the four departments of Dakar, Guédiawaye, Pikine and Rufisque, 43 municipalities and three rural communities.

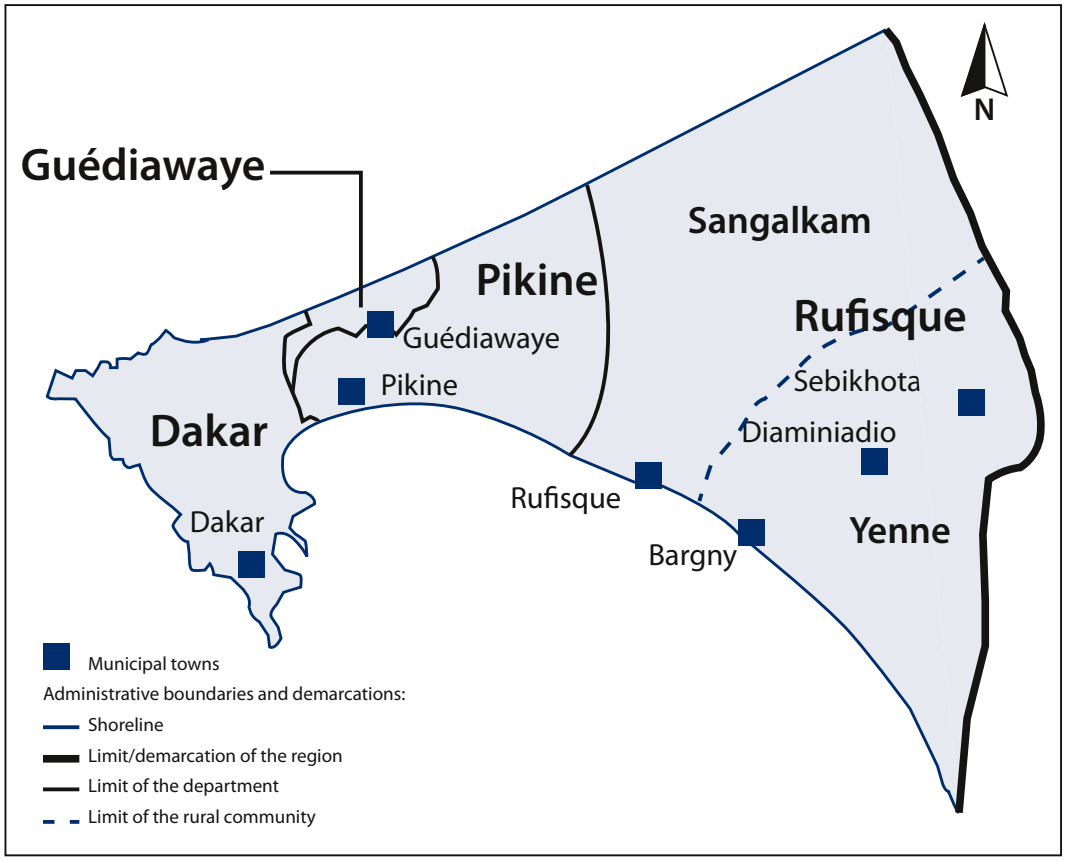


FIGURE 1.1
Administrative map of Dakar region
Source: Department of Statistics, Government of Tamil Nadu

In 2009, the urban population of the Dakar Region was estimated at about 2.5 million people, nearly three times its population 30 years ago (ANSD, 2010). According to data from population censuses, the population of Dakar in 1976 was 892 127. This figure increased to 1 488 941 in 1988 and 2 167 793 in 2002. The rate of population growth, which was 4 per cent between 1976 and 1988, has since stabilized at around 2.8 per cent. The proportion of urban population in the Dakar region has increased from 88.4 per cent in 1976 to 97.2 per cent in 2008 (ANSD, 2009). The rapid urbanization of the area can be attributed to natural growth and to immigration from other regions and

neighbouring West African countries, owing to its role as an administrative, political and economic hub, with relatively well-developed infrastructure. The Department of Dakar is the most populated with 41.0 per cent of the Dakar Region's population, followed closely by the Department of Pikine at 36.6 per cent. The Departments of Guédiawaye and Rufisque are less populated with 12.3 and 10.1 per cent, respectively, of the region's population (ANSD, 2009).

As in many developing countries, Dakar has a number of environmental and structural constraints linked to the high concentration of urban population in the capital. These include:

- Poor solid waste management resulting from organizational and institutional lapses in planning and implementing systematic waste management. This situation results in weaknesses in solid urban waste collection, transportation, processing and disposal. The main waste dump in Dakar, Mbeubeuss, receives close to 457 000 tons of waste annually. Located in a dried-up lake, it is at the limit of its capacity (IAGU and UNEP, 2009).
- Transport-related pollution is increasing due to the expansion of the urban territory of Dakar and an increase in the vehicle fleet, which is growing in tandem with the population.
- Groundwater quality in Dakar is deteriorating, with nitrate levels well above the maximum permissible concentration of 50 mg/l set by the World Health Organization (WHO) for potable water. In the area of Malika around Mbeubeuss, 75 per cent of potable water points are contaminated with lead, cadmium or aluminium. Biological contamination is also a concern, with water quality at 87 per cent of sites below WHO standards for use in unrestricted irrigation of vegetables that are eaten raw (Niang *et al.,* 2007).
- Climate hazards are increasing. Senegal, as with the Sahel region more generally, is subjected to high inter-annual variability in rainfall. Although the region has recovered from the serious droughts of the 1970s and 1980s, below-normal rainfall years are a recurrent risk. Additionally, increasing urbanization of the Dakar Region appears to be lowering the threshold for flooding triggered by intense rainfall. The Dakar Region is becoming warmer as evident by an increase in both maximum and minimum temperatures since the late 1970s. Climate projections indicate that warming trends in the Dakar Region are very likely to accelerate and the region will experience changes in rainfall, though there are significant uncertainties in the climate models with respect to the direction and magnitude of that change.

Urban and peri-urban agriculture (UPA) is a prominent feature of the Dakar Region, which includes the metropolitan area of Dakar, the towns of Pikine and Rufisque and the traditional villages of Thiaroye, Yeumbeul, and Malika. The vast majority of UPA occurs in the *Niayes*, a geological depression with a high water table that runs through the region. Farming in the area meets approximately 60 per cent of total demand for vegetables in Senegal while also supplying vegetables for export to the West Africa region and beyond. Urban agriculture absorbs a significant portion of manpower and provides economic resources to different categories of actors—producers, farm employees, traders and middlemen. Physical space for UPA is in high demand for non-agricultural purposes and is the subject of disputes, negotiations and renegotiations.

2 Objectives and methods

The assessment was conducted using a combination of secondary data sources including academic literature, reports, proceedings, etc., along with site visits and focus group discussions in three farming locations (Pikine, Sangalkam and Mbao), which involved various actors, including farmers, city councillors and ministry staff. The study was conducted by an eight-member multi-disciplinary team of experts working on various issues of agriculture, the environment and climate change under the coordination of IDEV–ic, a Senegalese consulting firm. These experts are Yacine Badiane Ndour (ISRA), Marie Sophie Ndong (IDEV-ic), Mouhamadou L. Dial (UCAD), Jean-Pierre Yvon Fall (IDEV-ic) and Idy Niang (Environment Ministry). The original coordinator of the assessment was Mamadou Khouma. He passed away in April 2012, and was replaced by Moussa Sy. Mohamed Oumar Diagne was also part of the team; he passed away in 2013.

The study was launched at a workshop attended by various actors of urban agriculture, including ministerial departments, decentralized bodies, non-governmental organizations (NGOs), farmers, researchers and the media, that was held in Dakar in June 2011. At this workshop, the assessment's objectives, as well as the human and technical components of the study, were discussed. Subsequently, an eight-member assessment team was established, and it convened several times in developing this report. The assessment's conceptual framework illustrates the key drivers and stressors, development factors and urban and peri-urban services. The assessment framework is presented in Figure 2.1.

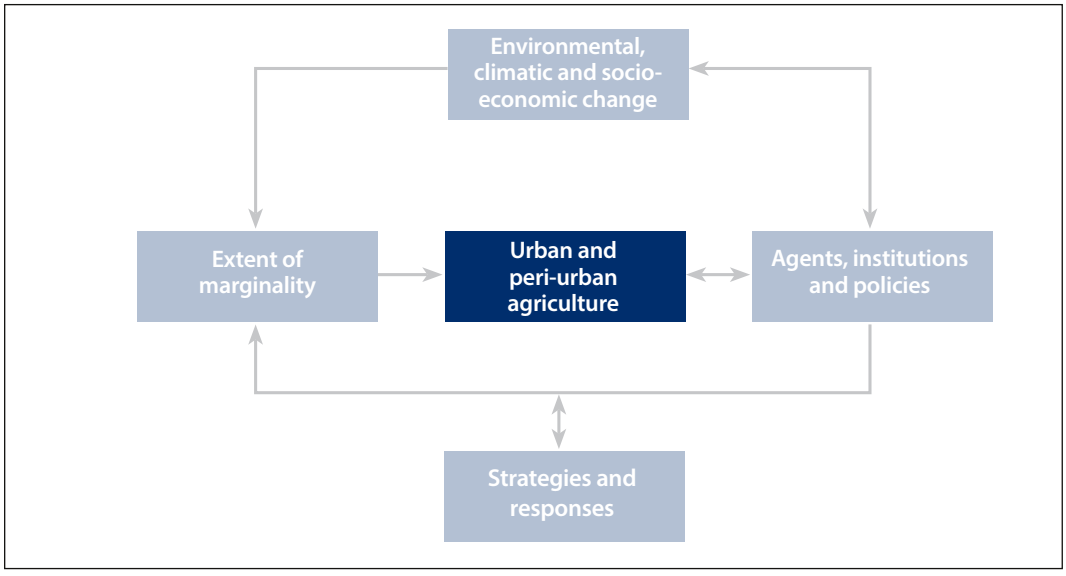


FIGURE 2.1
Conceptual framework

The objectives of this assessment are to:

- assemble and synthesize knowledge on agricultural activities in urban and peri-urban areas of Dakar, and provide scientifically credible information that supports policy planning and decision-making at the city level;
- identify where insufficient knowledge exists and highlight where additional research and assessment efforts are needed; and
- strengthen capacity within the research community to undertake assessments, and foster networks of regional technical expertise, and to encourage stronger communities of practice engaged in the topic of urban food production and climate change.

3 Climate trends and projections in Dakar

Temperature trends and projections

Analyses of maximum and minimum temperature anomalies (Figures 3.1 and 3.2) indicate a warming trend over the past six decades, particularly since the 1990s.

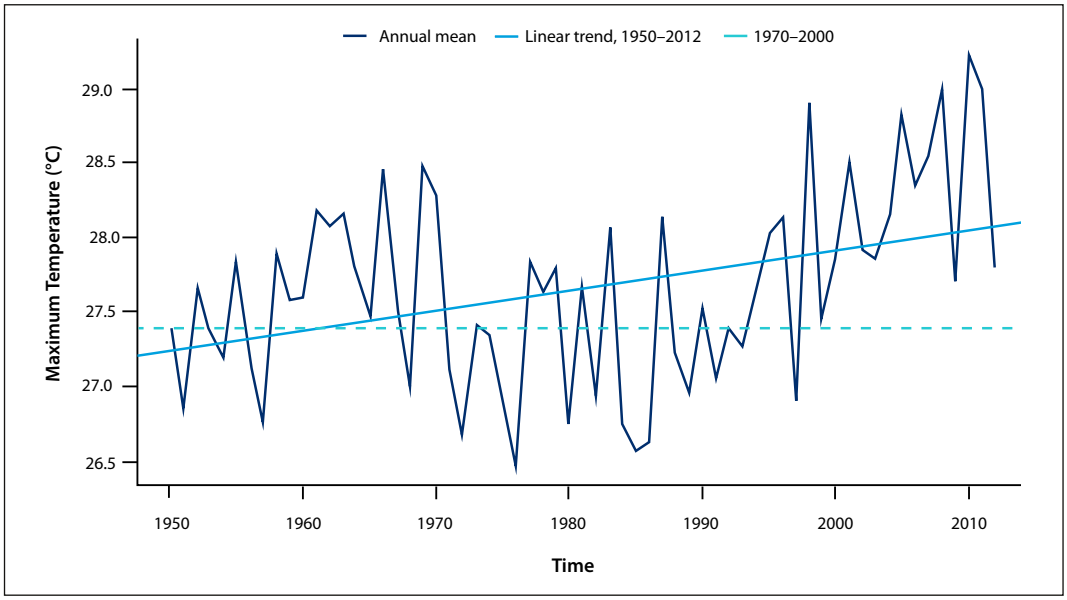


FIGURE 3.1
Maximum temperature time series for Dakar, 1950–2012
Source: ANACIM, 2013

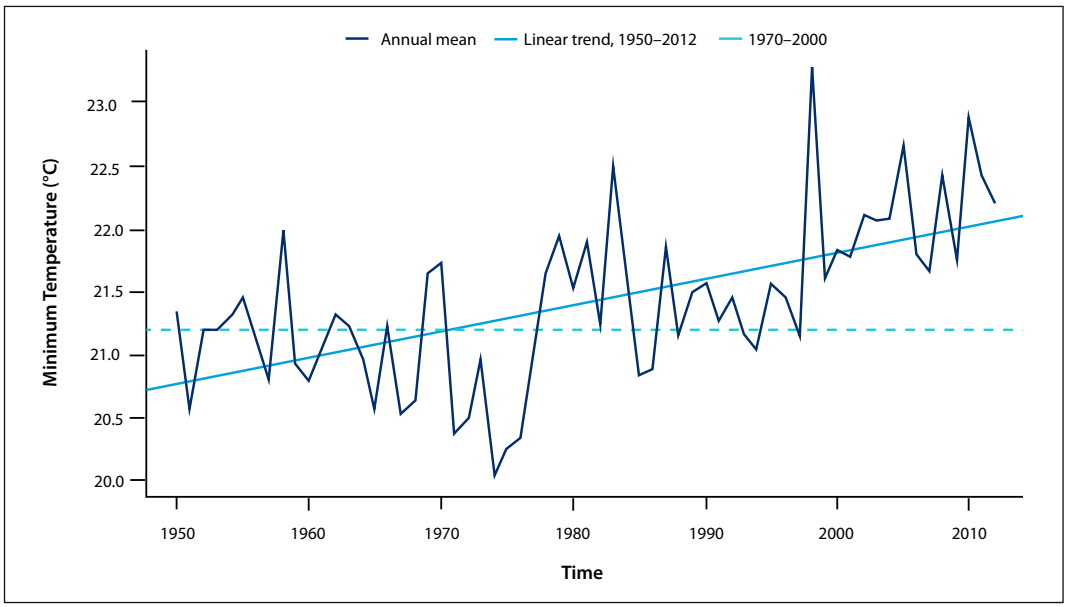


FIGURE 3.2
Minimum temperature time series and trend for Dakar, 1950–2012
Source: ANACIM, 2003

The warming trend is expected to intensify over the course of this century. Figures 3.3a, b and 3.4a, b below show an envelope of projected temperature change derived from a suite of regionally downscaled climate model projections from CMIP5[1] under a future scenario of low greenhouse gas emissions (Representative Concentration Pathway [RCP] 4.5)[2] and a future scenario of high greenhouse gas emissions (Representative Concentration Pathway [RCP] 8.5).

The temperature projections are given as anomalies (i.e., how much the mean monthly temperatures for the projected period differ from historic mean monthly temperatures) for the 2040–2060 period relative to the observed period of 1981–2010. The bars represent the range of temperature change, and the lines represent the different models that were used to derive the bars. Short bars indicate close agreement between the model projections, and thus relatively greater certainty, while tall bars indicate a wide spread of the model results and less overall certainty as to the amount of change. Thus, for example, in Figure 3.3a, projections for the months of June show close agreement between the models indicating a higher level of certainty as to the magnitude of projected temperature change, whereas March has a much wider band of projected temperature change, indicating relatively greater uncertainty as to the magnitude of temperature change.

The low and high emissions scenarios for the 2040–2060 period exhibit a similar pattern in that the extent of projected warming will be greater in the October to January period than in the February to September period. The RCP 4.5 (low emissions) scenario indicates that maximum temperatures will increase by a range of around 0.5–1.5° C during February–September and around 1.5–2.0° C in October–January (Figure 3.3a), and RCP 8.5 (high emissions) will increase by a range of around 1.0–1.5° C during February–September and around 1.5–2.5° C in October–January (Figure 3.3b). The change in minimum temperatures exhibits a somewhat similar pattern to that of maximum temperatures in that the extent of warming is lowest in the rainy season and greatest in the short hot season following the rainy season and in the winter Harmattan season. The range of the increase is about 1.0–2.0° C across the low and high scenarios.

The close agreement between the high and low emissions scenarios for maximum and minimum temperatures indicates that the likely rate of warming is well represented over a range of greenhouse gas emissions trajectories. The projections are for the city of Thiès, located approximately 35 km east of Dakar. No projections data was available for Dakar proper, however the Thiès data is likely to be quite indicative of future temperature change for the Dakar Region.

1 CMIP5 stands for phase 5 of the Coupled Model Intercomparison Project. See http://cmip-pcmdi.llnl.gov/cmip5/index.html

2 The emissions scenarios are based on the IPCC 5th Assessment Report scenarios. See http://sedac.ipcc-data.org/ddc/ar5_scenario_process/index.html

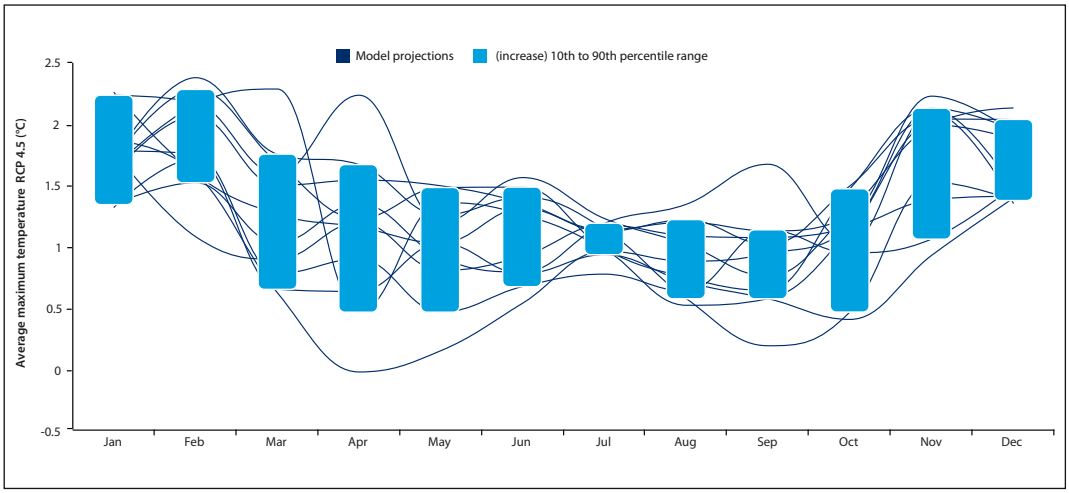


FIGURE 3.3a
Maximum mean monthly temperature, RCP 4.5

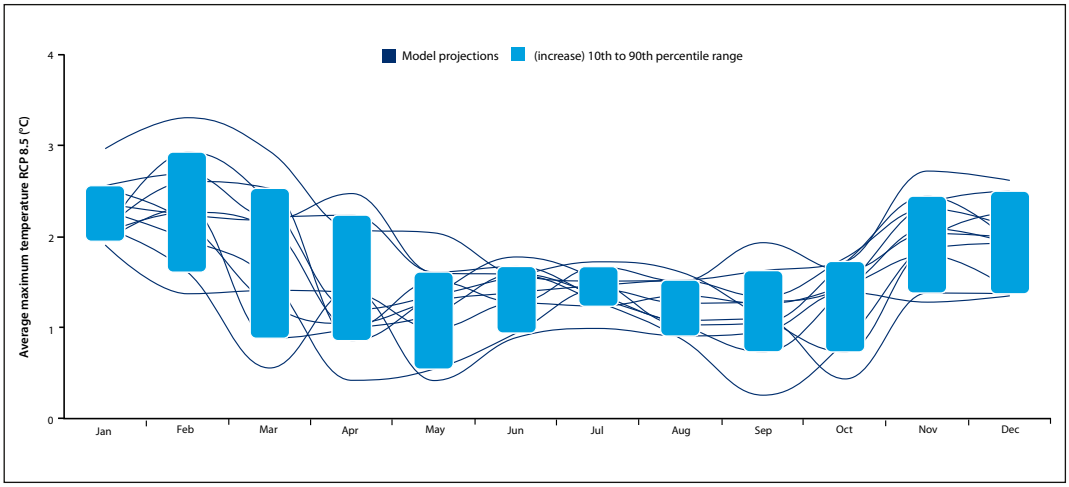


FIGURE 3.3b
Maximum mean monthly temperature, RCP 8.5

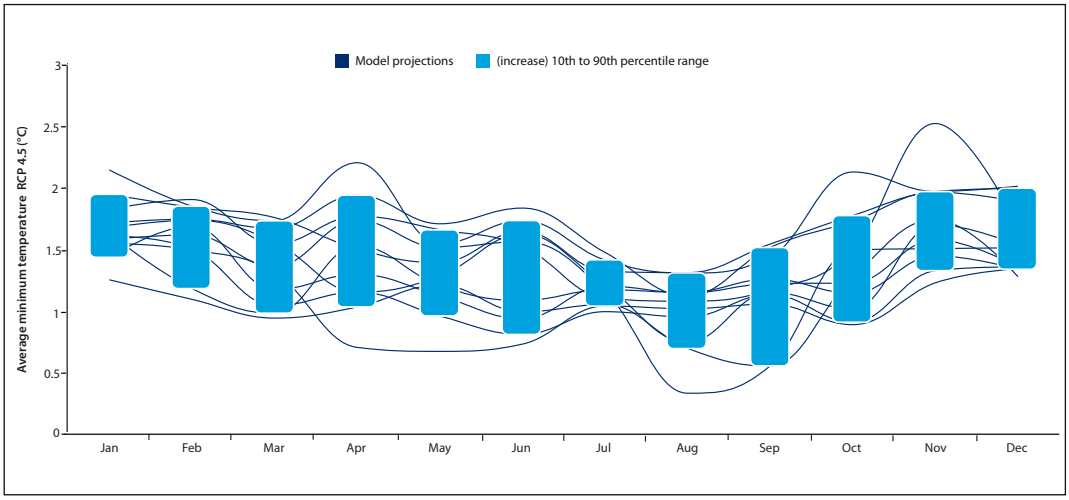
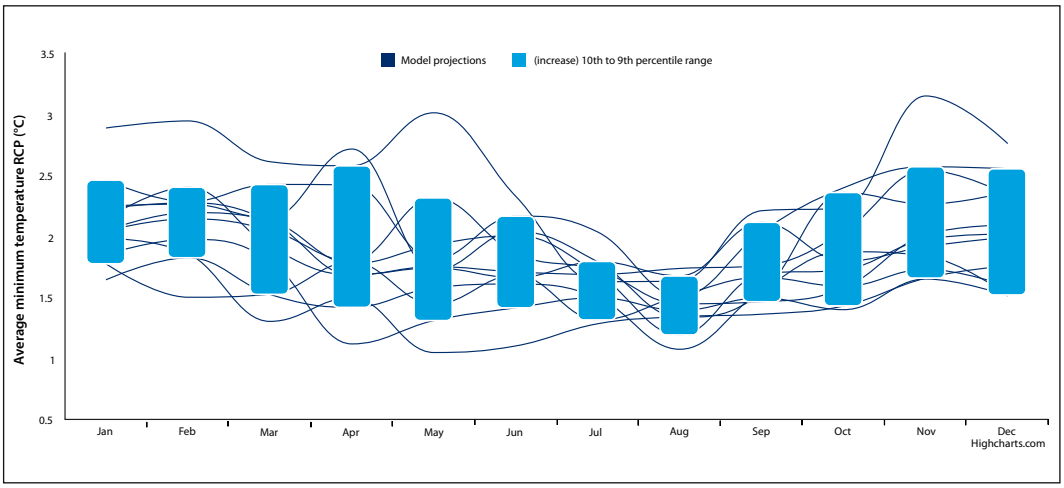


FIGURE 3.4a
Minimum mean monthly temperature, RCP 4.5

FIGURE 3.4b
Minimum mean monthly temperature, RCP 8.5

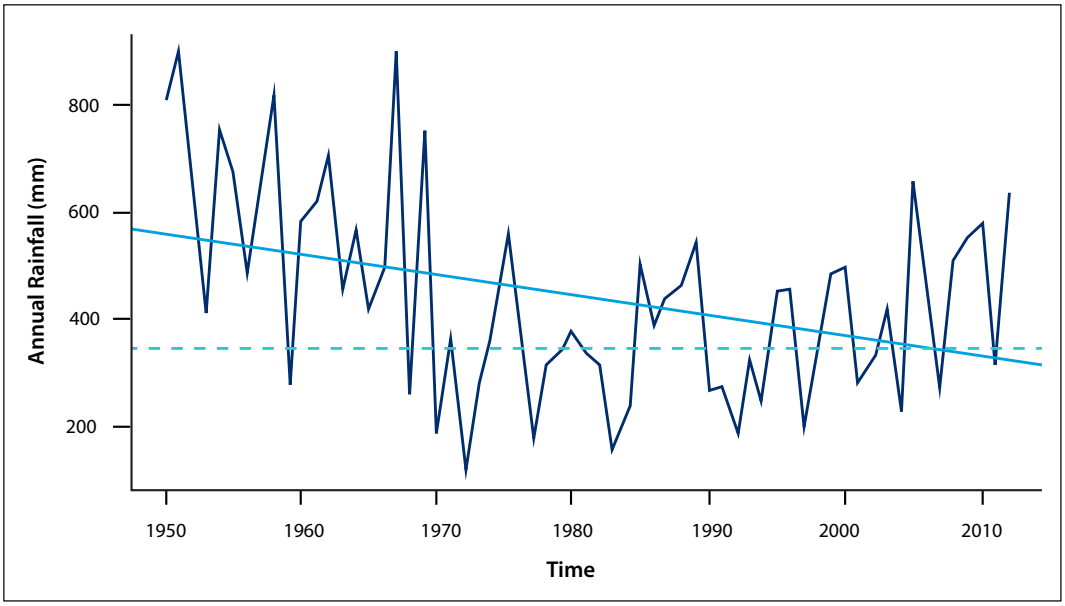


Rainfall trends and projections

The Dakar region, as in the West African Sahel more generally, experiences high inter-annual seasonal variability with respect to rainfall. The region has largely recovered from the devastating droughts of the late 1970s through the 1980s, though has not returned to pre-drought rainfall levels of the mid-20th century (Figure 3.5).

Precipitation projections are presented for the city of Thiès, located 35 km east of the Dakar region. Figures 3.6a, b show an envelope of projected precipitation change for the 2040–2060 period compared with the historic baseline period of 1981–2010. The figures were derived from a suite of regionally downscaled climate model projections from CMIP5, under future scenarios of low (RCP 4.5) and high (RCP 8.5) greenhouse gas emissions, and were obtained from the University of Cape Town's Climate Information Portal. The blue bars represent positive anomalies (increased rainfall), and the turquoise bars negative anomalies (decreased rainfall) relative to historic monthly means.

FIGURE 3.5
Annual rainfall time series and trend for Dakar, 1950–2012
Source: ANACIM, 2013



The grey lines represent the individual model results. As with previous figures, the height of the bar indicates the degree of model agreement; the shorter the bar, the greater the degree of agreement of rainfall projections between models, and thus the higher degree of relative certainty with respect to the future. The distribution of the bars is also important. Bars that are distributed predominately in one direction relative to the zero line indicate agreement between the models regarding either increasing rainfall (the bar is mostly above the zero line) or decreasing rainfall (mostly below the zero line). Bars that evenly straddle above and below the line show poor agreement as to the direction of future rainfall.

Both the low and high emissions scenario analysis indicate that the months of September and October could receive increased rainfall by mid-century, while July and August show that either increased or decreased precipitation is possible (Figures 3.6a, b).

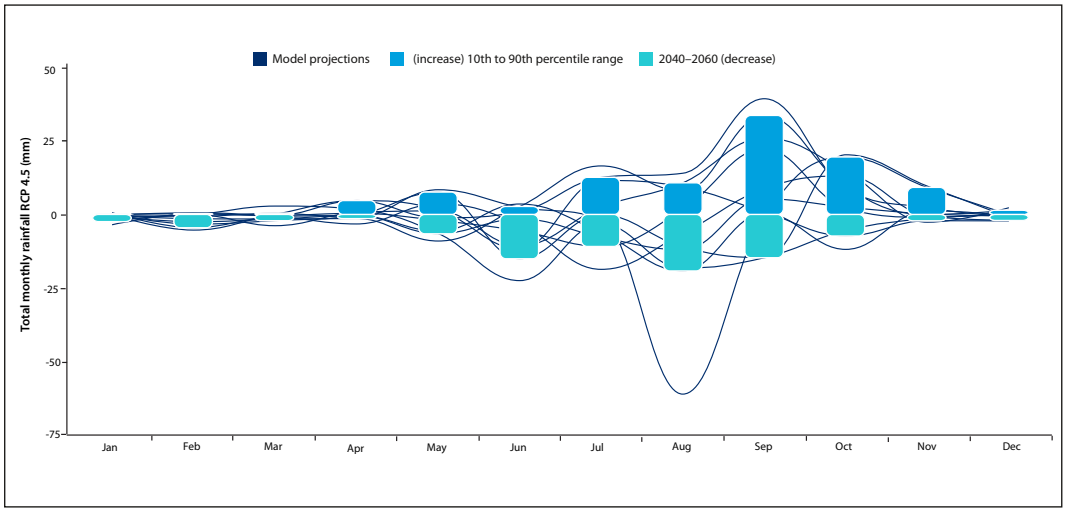


FIGURE 3.6a
Change in mean monthly rainfall 2040–2060, RCP 4.5

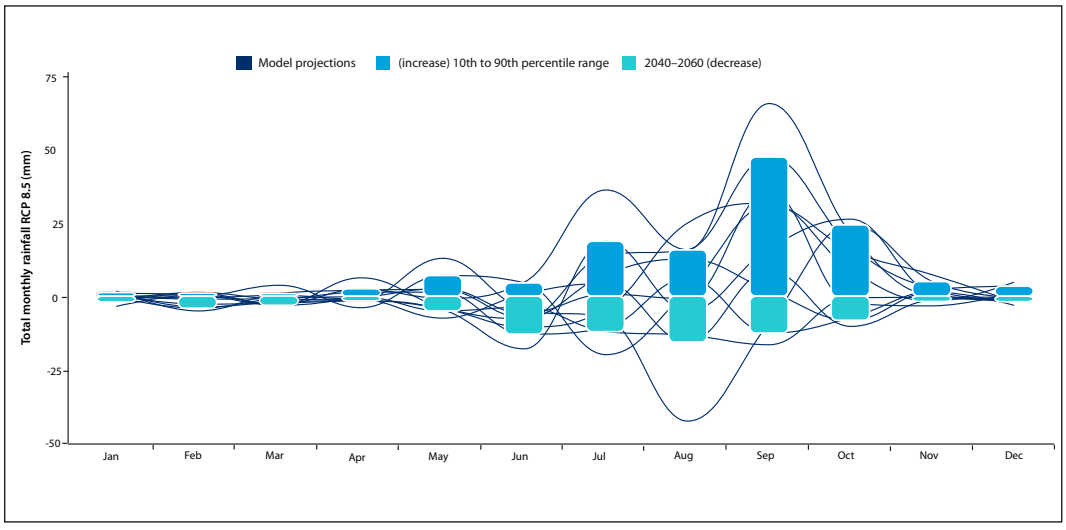


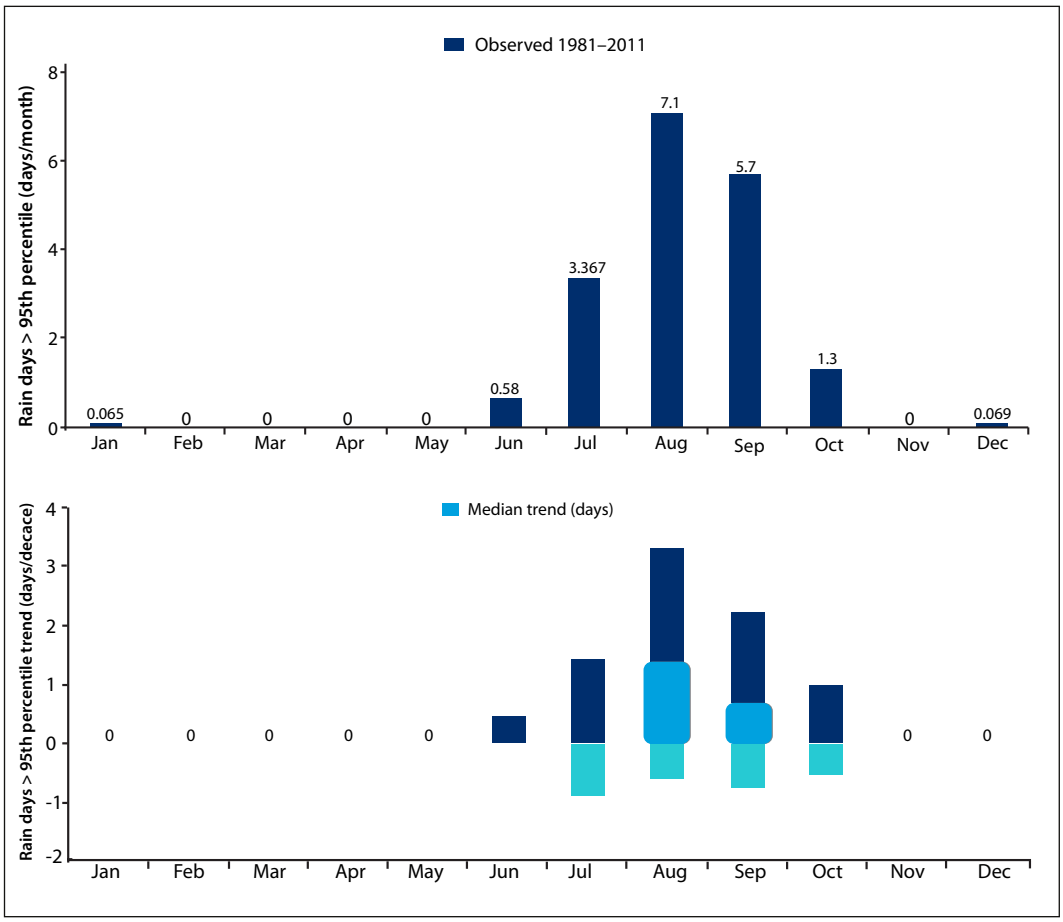
FIGURE 3.6b
Change in mean monthly rainfall 2040–2060, RCP 8.5

Heavy rainfall events, trends and projections

Thiès, Senegal, shows very high frequency of heavy rain days in August and September, with August experiencing, on average, 7.1 days of heavy rainfall (Figure 3.7a). The trend analysis indicates that August has experienced an increase in extreme rain days of the order of 1.3 days/decade over the observed 30 years (Figure 3.7b). Statistical analysis of rainfall data from the city of Dakar (Sene and Ozer, 2002) shows that heavy rainfall events, sufficient to trigger flooding, have a return period of 6 years for Dakar. The 156 mm of rain recorded in Dakar on 26 August 2012 represented a greater than 1 in 30 year return period.

Near-term (2040–2060) projected changes do not show much agreement on changes in the frequency of extreme rainfall days though most of the models show increases in September (Figure 3.8b). It is important to note that the projections presented here are for a single point location. Large-scale flooding events can occur due to rainfall within a small, localized region. However, often, flooding events are the result of larger-scale catchment dynamics resulting in high river levels and high soil moisture content. Under such conditions, heavy local rainfall can lead to localized flooding. In coastal locations, interaction with storm surges can compound from the flooding potential of a local-scale rainfall event.

FIGURE 3.7a, b
Monthly averages for heavy rainfall days: those exceeding the 95th percentile of normal distribution (top figure), and trend in changes in heavy rainfall days (bottom figure), for the period 1981–2011



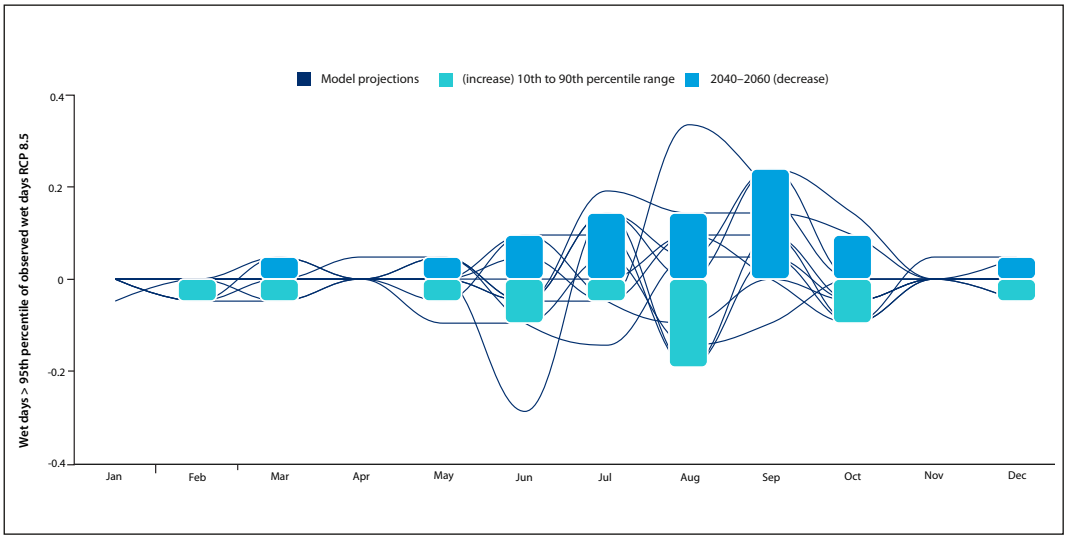


FIGURE 3.8
Projected changes in heavy rainfall days for the period 2040–2060 compared with observed (1981–2011)

FIGURE 3.9
Extent of flooding (blue areas) in Dakar following heavy rainfall and severe storm events of September 2010

Source: ASI, 2010

The major results of the RegCM3 (regional climate model, version 3) used in Senegal's Second National Communications are summarized in Table 3.1.

TABLE 3.1
Climate Projections

Climate parameters	Trends in relation to climate change
Temperature	A general increase in temperature is anticipated all over the period 2031–2100, compared to present climate.
Rainfall	The number of days of high-intensity rainfall tends to be 5 per cent higher for the period 2031–2050 compared to the period 1980–2000.
Humidity	The Dakar region may be more flood-prone due to heavier rains linked to greater atmospheric humidity resulting from rising temperatures. Rising temperature could increase monsoon flux, transporting more humidity from the ocean to the continent. Evaporation could also be more important. One has also to consider that all the humidity excess can also be transported out of the continent by the anticipated high speed of the East African Jet Stream (Gaye and Sylla 2008).
Extreme events (floods, drought, storms, heat)	The regional model known as RegCM3 forecasts fewer wet sequences and an increase in dry sequences in the Dakar region for the period 2031–2050.

Flooded streets in Dakar's Pikine Department where roofing materials have been removed from several abandoned homes. © John Scott-Railton

4
Characteristics of UPA in Dakar

Physical characteristics

Urban and peri-urban agriculture in the Dakar Region mostly occurs in the *Niayes* coastal strip, a fertile and important agricultural and market gardening area, which provides nearly 60 per cent of Dakar's vegetables (Dasylva, 2012). The *Niayes* refers to a specific ecological zone of northern coastal Senegal comprising a system of wet depressions bordered by sand dunes. The *Niayes* represent an important reservoir of biodiversity of the Cap Vert peninsula, though one that is under intense pressures from human settlements. Of the 31 plant species endemic to Senegal, 13 are found in the *Niayes* ecosystem (Ndiaye, 1998; Dasylva, 2012). Animals including jackals, monkeys, warthogs, hyenas, squirrels, hares, palm rats, Nile monitors, civets, porcupines and various kinds of snakes, as well as 133 bird species are found in the area, including 40 endemic, 25 migratory and 51 nesting species (Ministry of Environment and Sanitation, 2003).

A defining functional characteristic of the *Niayes* is that the groundwater reaches, and in some cases overflows, the soil surface. This hydrologic process provides important water resources that sustain various economic, environmental and social services (Dasylva, 2012). The four main types of environments within and around the Dakar Region are:

- *Diors*: Tropical ferruginous soils that occur in about 70 per cent of the entire Dakar Region, and are mostly found in the greater Pikine *Niayes*.
- *Niayes*: Consisting of inter-dunal depressions characterized by very shallow moist soils, occasional surface waters, and Guinea-savannah vegetation. These sites are typically large and spread out longitudinally on the Cap Vert peninsula—the Patte d'Oie *Niaye*, Pikine *Niaye.Valleys or dried-up lakes*: Originating from ancient hydrographic networks that have dried up. These are found around Youi, Mbeubeus, Malika, etc.
- *Ndiouki*: Salty basins located in the active dune system and the semi-fixed dunes found just outside the Dakar Region.

Farming systems in the *Niayes* mainly consist of:

- *Small market-garden farms of less than 1 ha.* Eighty-four per cent of farmers in this category have relatively small plots, with cultivated parcels varying between 150 m^2 and 500 m^2 in the case of market gardening, and 200 m^2 for floriculture (DA, 2011). These small parcels of land are divided up by their owners who either rent them out or lend them to nationals or migrants from neighbouring countries, particularly Guinea Conakry, on a share-cropping basis. This type of farming is dominant in the *Niayes* and the dried-up valleys. The main crops grown are cabbage, pepper, onion, lettuce, peppermint and jaxatus, among others and are basically grown to supply the local markets of Thiaroye, Cambérène, Castor, Marché Kermel, etc.

Niayes landscape

- *Medium-sized market-garden farms of 1–20 ha.* These are gardens, which are acquired either through inheritance, purchase, gift or rent. They are predominantly found on sandy soils (*Dior*) and clayey soils (vertisols) in the Sébikotane and Sangalkam zones on the eastern fringes of the region. Crops most commonly grown are onion, tomato, green beans, cabbage, eggplant, bitter eggplant, beans, pepper and capsicum, and production is essentially for wholesale and export purposes.

- *Large market-garden farms of more than 50 ha*. These are private or joint ventures of Groupement d'Intérêt Economique (GIE), which are mostly found at Sébikotane in the Department of Rufisque. Crops, particularly green beans and tomatoes, are mostly grown for export, although surplus products are sold at local markets.

- *Aboriculture is also widely practiced*. The main crops are coconut, mango, pawpaw, soursop (*Annona muricata L.*) and citrus fruit. The main production sites are in peri-urban zones, where arboriculture is often combined with vegetables gardens.

Farming activities are located in the Pikine *Niayes* where the Patte d'Oie site is located, as well as in the Technopole, along the highway, and in the Keur Massar, Lendeng, Malika and Yeumbeul *Niayes* areas, and the Mbao Forest Reserve (Figure 4.1), which is home to approximately 2 500 farmers. Overall, the combined areas available for urban agriculture are rather limited (less than 200 ha) and farming generally occurs on hydromophous soils. Water for irrigation is drawn from very shallow wells 1–10 m deep called *Céanes.* Small-scale farming is done side by side with medium- and large-

scale farming (PDMAS, 2009). Larger agricultural plots and a wide existence of poultry and cattle are located at the periphery of the region.

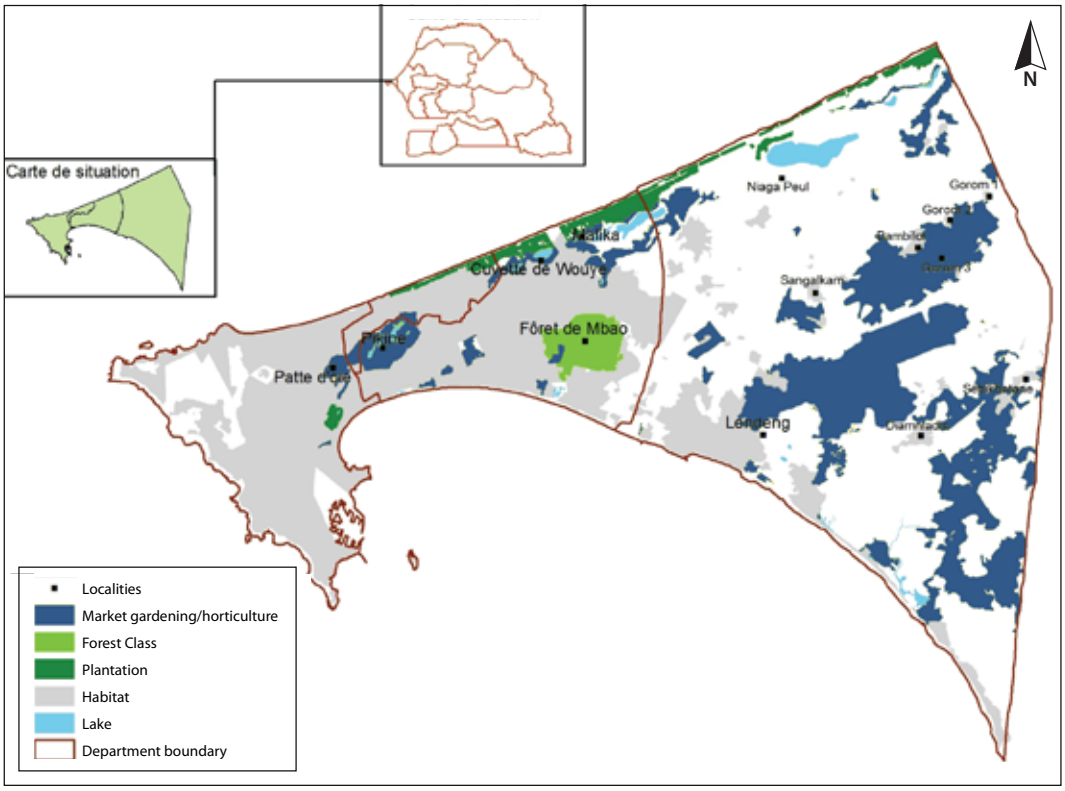
Economic characteristics of UPA in Dakar

The socio-economic importance of UPA in the Dakar region is linked to the fact that 200 000–250 000 people derive a portion of their income from market-garden farming (Fall *et al.*, 2003). While economic activities in the Dakar Region are predominantly generated from the industrial and service sectors, Sueur (2011) estimated that 26 per cent of the population derives revenue from agricultural activities, 6 per cent of whom depend exclusively on agriculture. The Households Senegalese Survey (ESAM II) states that farmers, farm workers and fishing represented only 2.6 per cent of the population of Dakar in 2004. These somewhat contrasting findings point to the need for updated rigorous assessments of livelihoods derived from UPA in the Dakar region.

The two main urban agricultural sites are those of Pikine and Patte d'Oie, which have a total cultivated area of 137 ha of intensive farming, 23 per cent of which is irrigated with wastewater. Anne Guèye Girardet (2010) estimated the cropped area of Pikine and Patte d'Oie to be around 137 ha, covering sites of Pikine, Patte d'Oie and also other sites of Pikine Department like Malika and Thiaroye.

Farmer watering with "céanes" water

FIGURE 4.1
Main locations of UPA in Dakar
Source: iDev-Technologies, 2013



In addition to supplying vegetables directly to Dakar, agricultural production in the Dakar Region provides an important source of export earnings. The export market for horticultural products, such as green beans, mangoes, tomatoes and watermelons, has stimulated production, with recent estimates indicating that more than 4 000 ha are under cultivation, creating more than 18 000 direct agricultural jobs and more than 10 000 post-harvest jobs (ANSD, 2009).

The export market for horticultural products (e.g., green beans, mangoes, tomatoes and watermelons) has stimulated production (ANSD, 2009), with recent estimates indicating that more than 4 000 ha are under cultivation, creating more than 18 000 direct agricultural jobs and more than 10 000 post-harvest jobs (PPEA, 2001). Specific evaluation (Diarra, 2003) of some fruits and vegetables showed that these export networks directly generate 9 937 mostly seasonal jobs, with the number of months varying according to product and activities.

Export fruit and vegetable production is estimated to generate over FCFA 1 billion a year in wages, out of which FCFA 431 million is paid to rural female workers, who seasonally migrate to the region for agricultural employment, while FCFA 454 million is used to pay rural male workers (Diarra, 2003). Export of horticultural produce has experienced significant growth between 2000 and 2008 in the Dakar Region, increasing from almost 10 000 tons to more than 23 000 tons. In terms of volume, green beans accounted, on average, for 57 per cent of horticultural exports; tomatoes for 13 per cent and mangoes for 10 per cent. In 2008, green beans, tomatoes, mangoes and watermelons represented 95 per cent of total exports (ANSD, SES Dakar, 2008) and in 2009, fruit and vegetable exports exceeded 30 000 tonnes (Horticulture Directorate, 2012). A significant portion of these exports come from peri-urban areas of Dakar where some producers have obtained farmland size exceeding 20 ha.

The economic value of UPA extends to broader employment opportunities for the poor in related activities. It employs a host of people as sowers and gardeners, employed on either a temporary or permanent basis, and is also an important source of urban and rural secondary and tertiary employment in the transport, marketing, storage and processing sectors, as well as urban waste sorting activities, where very low-income people in such parts of Dakar as Croissement Cambérène and the Mbeubeusse retrieve and sell organic waste, which flower farmers use for soil amendment. No data is available on the extent of secondary economic activity linked to UPA in Dakar.

Characteristics of producers

An analysis carried out by the team using secondary data found that both men and women are involved in all horticultural zones in the Dakar Region. Farm managers are predominately men who are in charge of crops and are also responsible for bulk and semi-bulk sales and transportation of products from one region to another. In Dakar and Thiès, some women manage farms but their number is quite small (around 10 per cent of total farms) relative to men (Pre-census peri-urban farming, 1999/2000). Generally, women are engaged in distribution, marketing and sale of agricultural products in rural and urban markets. In the fruit and vegetables commodity systems, women play a particularly important role in establishing marketing networks (Mbaye and Moustier, 2000). Recently, women have begun participating in agricultural exporting where they are actively employed in the harvesting, sorting and packaging of groundnuts, tomatoes and green beans. According to Diao (2004b) in a summary article for the Resources Centres on Urban Agriculture and Food Security (RUAF), "*women and young girls make up 68 per cent of the labour force involved in harvest activities and 100 per cent in sorting and packaging activities*." Limited access to key production resources, particularly water and land, is often the reason why women tend to specialize in post-harvest activities. Women working in UPA generally do so to supplement their family income although the income realized is meagre as evident by their low standard of living and poverty-related vulnerabilities (Fall and Fall, 2001). All farms employ the services of children whose role is watering and harvesting of crops. In terms of actual profit accruing to actors, women and children are disadvantaged relative to men. Children involved in UPA do not go to school most of the time, and often work in unsafe conditions and are vulnerable to injuries. Estimates of UPA's total contribution to livelihoods of the poor are not available. This is an important knowledge gap.

Livestock

Information about livestock production in the Dakar Region is limited and much of it is outdated. Nonetheless, older studies cited in this section do point to a vibrant sector in the region. Livestock rearing in the Dakar *Niayes* includes space-intensive poultry and dairy production, both done in association with horticulture (Ba, 1999; Diao, 2004a). Dairy production consists mostly of local varieties of cattle and goat. Intensive dairy farming is beginning to develop in Dakar, but is vulnerable to space and feed constraints. Semi-extensive animal rearing also faces difficulties linked to rapid urbanization of the *Niayes*. Small ruminants used in diary production are sources of meat for the Muslim festival of Eid and are also supplied in limited quantities to restaurants. A RUAF summary by Fall *et al*., (2000) explains that "*Cattle and sheep rearing are also on the increase in all administrative regions of the Niayes zone. Non-conventional species like rabbit, ostrich, pigeon and turkey are also being raised through various small-scale enterprise diversification processes*." Increasingly, sheep rearing farms are emerging with such animal varieties as Toubabire, Bali-bali and Ladune imported from other parts of Africa. These varieties are highly patronised during religious festivals (Diao, 2004a). Yet, there is a significant lack of data on the amount and impact of this livestock rearing in Dakar.

Ultimately, land tenure remains a major constraint to further expansion in the urban livestock system in the Dakar *Niayes,* as housing and welfare are given priority in land allocation. Other constraints include the salinity of the soil and poor access to land (Cissé *et al*., 2006). These especially limit young and poor people who rely on livestock raising for livelihoods.

A well-established supply chain enables intensive poultry farming for broilers and layers, particularly in the upstream of the *Niayes* region. The system relies on a range of labour resources—hatchery operators, feed producers, equipment distributors, technicians, producer organisations, etc. (Diao, 2004a). According to a study by Mbaye and Moustier (2000), 65 per cent of national demand for poultry products is supplied by production in *Niayes*. Poultry farming generates waste that is used for fertilizing leafy vegetable crops (Djienor, 2009). Although this activity is well developed in the region, it is quite limited on family farms and is often associated with horticultural production, which benefits from the poultry waste.

Box 1. Past work on UPA in Dakar

For many years preceding this assessment, Dakar's urban and peri-urban agriculture has been the focus of research-development programmes initiated by national and international institutions. Examples of previous work on UPA in Dakar include:

The Institute of Research and Development of Canada (IDRC) was active in urban agriculture throughout the 1990s with its Urban Agriculture/Cities Feeding People programme. Its research focused on three major areas: production systems under limited space reserved for urban small-income farmers; treatment and reuse of residual water; and development of strategic and political instruments that enhance the activities of farmers.

The work of the Institut sénégalais de recherche agricole (ISRA) focused on hydroponic production of vegetables, recycling of wastewater and abattoir waste in agriculture and intensive diary production. In 2000, ISRA organised a forum on urban agriculture, which brought together a wide array of researchers, public administrators and private operators. With funding from IDRC, ISRA research culminated in a book entitled *Cités horticoles en sursis,* focusing on the characterisation of production systems, the impact of urban agriculture on the environment and the public health, land use, and the linkages between horticulture-livestock and the strategies used by various stakeholders.

Through the works of WWTL (Waste Water Treatment Laboratory) of IFAN (l'Institut Fondamental d'Afrique Noire), Université Cheikh Anta Diop (UCAD) has undertaken research on the chemical and biological characteristics of water used in urban agriculture in Dakar, assessed the impact of using wastewater in urban agriculture in Dakar in terms of yield and quality of crops and experimented with the purification of wastewater for reuse in urban agriculture.

With its partners such as IRD, CIRAD, ENDA GRAF or ISRA, the Group of Research and Technological Exchanges (GRET) stood out in terms of providing support to small urban farmers to enable them to access markets. GRET also initiated deliberations on the issue of peri-uban space management with its partners and that became a reality thanks to the design and implementation of an Ecocity action-research programme, which proposes to study the impact of making available information tools from shared diagnostics of the implementation of a real consultative process among stakeholders for a collaborative and sustainable management of natural and agricultural resources.

IAGU (Institut Africain de Gestion Urbaine—African Institute for Urban Management) through its Urban Agriculture office, is working towards fostering knowledge enhancement and capacity building with the view to augmenting the contribution of urban agriculture to sustainable development of African cities.

ENDA RUP has developed initiatives on urban and peri-urban agriculture and on urban agricultural systems.

Animal diseases in peri-urban intensive poultry production present a potential economic hazard for producers. A study by Cardinale *et al.*, (2003), which examined the contamination of poultry products through the production chain, identified several critical points. The speculative character of production and the potential profit have resulted in inexperienced urban dwellers with few skills to engage in poultry production in ill-adapted buildings and with very little concern and/or knowledge about the quality of products. Training of inexperienced producers and other actors is therefore key to improving quality and reducing human health risks (Cardinale *et al.*, 2003).

5 The policy environment

Environmental and health policies affecting UPA

There are currently two codes regulating urban agriculture and the use of wastewater for irrigation. These are the law on hygiene, N° 8371 of 05 July 1983, which relates to water use, and the urban code of law N° 88-05 of 20 June 1988, which relates to the urban agriculture component. In relation to the former, Article 41 stipulates that *"the discharge or deposit of solid waste, wastewater, domestic garbage, mud, faecal matter is prohibited on all lands where fruits and vegetables likely to be eaten raw and whose edible parts can come into contact with waste are grown. Manure and compost can only be applied at not less than one month before harvest. Fruits and vegetables must be free from soil. If it is necessary to wash fruits and vegetables, only potable water shall be used and this shall be followed by the adequate straining."*

This law, which is based on the World Health Organization (WHO) guideline values of 1992, needs to be updated to reflect current WHO guidelines, which no longer only consider microbiological concentration levels in irrigation water or vegetables but which now include notions of epidemiological risks linked to the reuse of wastewater in urban agriculture. Where means are available, WHO now recommends implementing measures for domestic wastewater to be treated to at least a secondary level for use in irrigated market gardening. However, the guidelines recommend that, whether irrigation water is treated or not, farmers comply with protective measures and good farming practices for irrigation, fertilization and disinfection of crops.

Legal and jurisdictional frameworks

Senegal has been slow to adopt an effective environmental protection policy for the Dakar *Niayes*. On 15 October 2002, the President of Senegal signed decree N° 2002.1042 ordering the development and implementation of an action programme for the preservation and urban development of the *Niayes* and the green zones of Dakar. Known as PASDUNE[3], the programme contained a requirement for a planning and preservation master plan (PPMP). The aim of the plan was to ensure the rational use of the *Niayes* and green zones of Dakar within a framework of sustainable development, and experts were given a maximum of two years to draw it up and ensure its approval. The PASDUNE programme was followed by another policy initiative, known as ATADEN, designed to provide technical assistance for the planning and development of the *Niayes*.

Thus Senegal has a legal framework with the potential to be conducive to the mainstreaming of UPA into urban planning master plans. If UPA could be mainstreamed into urban planning it would represent a significant departure from the conventional policy treatment in which UPA has neither

3 Le Programme d'Action pour la Sauvegarde et le Développement Urbain des *Niayes* et zones vertes de Dakar

been factored into town planning master plans nor into agricultural policies, and there has been no consultative process among local government bodies, the ministries of agriculture, urban planning, health and the Senegalese Sanitation Office (ONAS) about issues important for UPA.

As part of any effort to mainstream UPA into policy frameworks, there is a critical need to organize urban farmers under an umbrella organization that can work with municipalities to mainstream the horticultural zones of Dakar into town planning master plans or into the detailed urban plans of those areas that fall under the PASDUNE and ATADEN frameworks. Such an effort would contribute to securing legal recognition of the farming areas, which is important for the long-term sustainability of the sector, particularly for small-scale peri-urban farmers, most of whom acquire their land through customary law and as such lack formal land titles. However, PASDUNE, which was launched in 2002 on a two-year pilot basis, has not been implemented. There is a critical need to develop proactive land-use planning for the *Niayes* that discourages unregulated encroachment and includes urban agriculture and encourages the conservation of environmental services, such as floodwater management, that the *Niayes* provide.

Financing opportunities for UPA

Lack of access to appropriate credit mechanisms is often cited as a key impediment by farmers for managing risks and adapting to change, including climate change (Di Falco *et al*., 2011; Di Falco and Marcella, 2012). Urban and peri-urban farmers in Senegal are finding it increasingly difficult to access funding due to the lack of confidence on the part of financial institutions. As a result, there is a need to create dialogue between the various actors—farmers, policy makers, financial institutions and researchers—in order to find relevant and operational strategies for funding UPA.

6
The land resource base and UPA

Urban growth and land-use change

Rapid urban growth in the Dakar Region exerts significant pressures on land and water resources, with important implications for both peri-urban food production and flood risk management. Dakar's population has more than tripled since the last half of the 1970s (Figure 6.1), with much of the resulting urban growth occurring at the expense of farmlands in Pikine, Guédiawaye, *Niaye* and Rufisque (Figure 6.2). Wetland areas and areas within the Mbao woodlands are also under pressure from urban encroachment. This situation has dramatically changed the spatial structure of Dakar, whose residential land increased from almost 10 per cent of its total 53 640 ha area in 1980 to 36 per cent in 2001, while wooded land, farmland, flood-prone lands and vacant lands fell from 78 per cent to 51 per cent by 2001 (Diop, 2006). Similarly, the World Bank (2009a) estimated that urban surface area increased 25 per cent between 1998 and 2008, and that the largest population growth occurred in peri-urban areas with high hazard potential for inland flooding, coastal erosion and sea-level rise.

The pressure on the land base is certain to increase with population growth. In the 2002 census, the population of the Dakar region was estimated at 2 267 356. In 2006 it rose to 2 851 530 inhabitants, constituting 28 per cent of the country's total population (MUAT, 2003). According to the new Dakar urban master plan (PDU), Dakar's population is projected to approximately double by 2025 relative to the 2001 population.

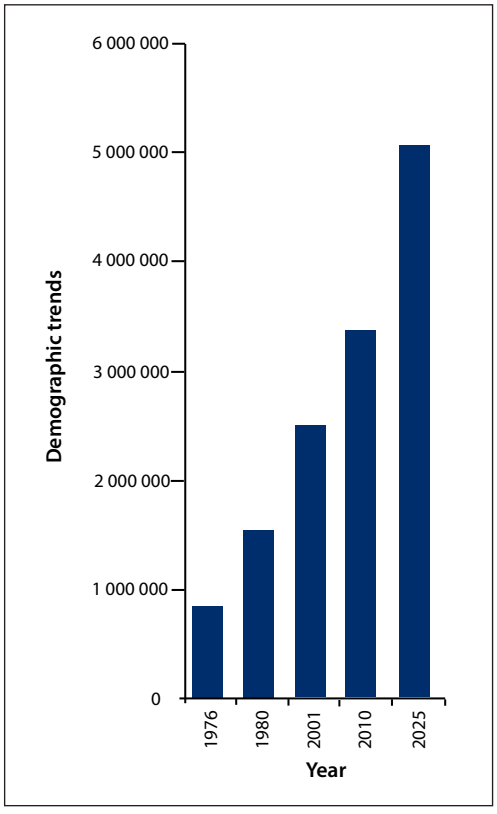
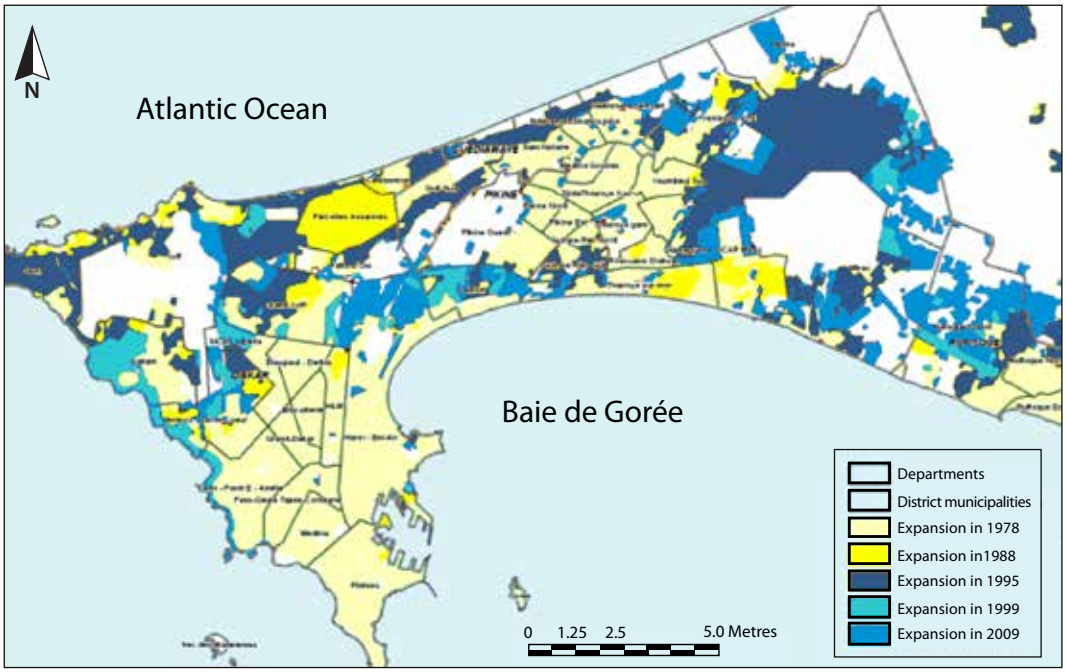


FIGURE 6.1
Demographic trends of the Dakar region
Source: PDU

Land-use change and flood risks

Over the past two decades Dakar has faced recurrent flooding problems, which are linked to the city's rapid urban growth and changing land-use patterns (Sène and Ozer, 2002; Dasylva, 2009; and Mbow *et al.*, 2008). For example, Mbow *et al.*, (2008) demonstrated how flood risks facing the urban poor have increased as a result of rapid infilling of the *Niayes* depressions with poorly constructed housing in the Yeumbeul suburb of Dakar (Figure 6.3). Long drought periods in the 1970s and 1980s, combined with a rapid urbanization of Dakar suburbs, favoured settlement expansion on lands in this area that used to be dominated by market-garden farming and natural vegetation. According to Mbow *et al.*,

FIGURE 6.2
Expansion of urbanized surface in Dakar between 1978 and 2009
Source: Instituto Agronomico per l'Oltremare; EC-JRS



(2008) "*in 1954 natural vegetation was the dominant soil cover; in 1978 the scenario shows competition between houses and peri-urban agriculture, and by 2003, there was no longer place for either peri-urban agriculture or for natural vegetation.*" Thus, Dakar's peri-urban areas are transitioning from a landscape dominated by vegetation to one dominated by settlements.

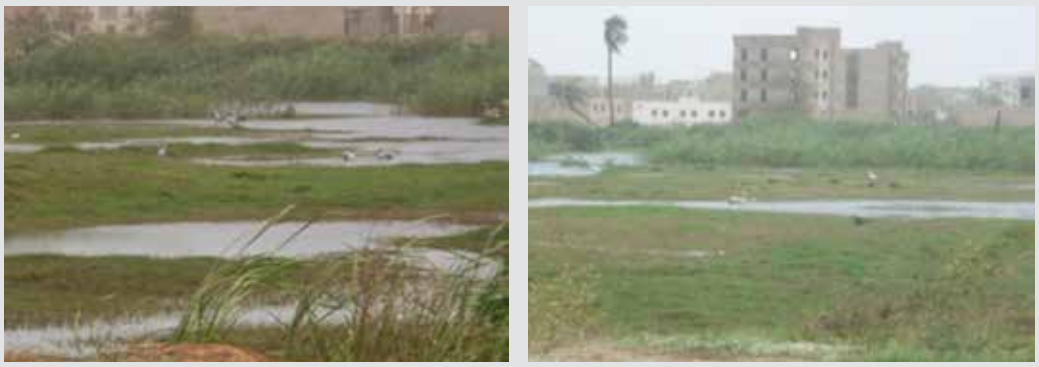
Recent flooding in Dakar could have been worse had it not been for the presence of the *Niayes* depressions. In the lowest points of the city, these depressions accumulate running water due to the general impermeability of the soil upslope as a result of housing construction and road infrastructure. There is strong potential for flood risks to increase in the future, given the likelihood of increased frequency of high-intensity rainfall events in combination with a shift towards land surfaces with low permeability due to housing and road and infrastructure construction.

To address an intensifying threat from urban floods, planning processes are needed that would integrate climate considerations into land-use planning. Such processes should be supported by in-depth assessments to estimate the extent to which flood risks could increase with current and future pressures on land-use conversion in sensitive areas, such as in *Niayes* urban agricultural lands, and projections of changes in rainfall characteristics. Such an assessment would also take into account the changing nature of flood risks to UPA production. As described in Section 3, the vast majority of horticultural production for both the Dakar market and export occur on lowland, flood-prone sites with a high groundwater table. Future action should also take into account the possibility of successive dry years and the subsequent impacts of reduced availability of irrigation water. These are all important knowledge gaps.

Box 2. Land-based planning solutions for flood risk management—Thiaroye aquifer and L. Wouye

The lake system within the *Niayes* is being increasingly viewed for its potential to help Dakar to more effectively address recurrent flooding of its suburbs. Specifically, the Government of Senegal has in its 2010 Action Plan called for the development of a network between the Thiourour, Ourouwaye and Wouye lakes that will receive runoff water through a gravity-based drainage system in which flood waters can be collected in these lakes and drained to the sea using powerful electric pumps. To cope with economic consequences of Lake Wouye overflow, the State of Senegal compensated urban farmers who were affected.

Lake Wouye is part of a system of lakes within the *Niayes* that stretches along the coastal belt from Dakar to Saint Louis. The lake is located in the suburb of Dakar (Yeumbeul-Malika), and was formed in a geological depression stretching along the same direction as the sand dunes that surround it. In recent years, as a consequence of irregular pumping to the sea, Lake Wouye periodically overflows and submerges cropped plots around the lake. Cropped areas around the lake have been noticeably reduced, resulting in some farmers abandoning farming because of the lack of suitable land. Food production in the lake ecosystem has also been disrupted by invasive aquatic plant (Typha), which has reduced fish catches.



Expansion of settlement into the *Niayes*

Land revenue is one of the major drivers of urban change in the city of Dakar. The high demand for land in Dakar, and the influence it has on the profitability of converting farmland to real estate, presents a strong counterweight to efforts towards policy recognition of UPA. Currently, buying a plot of land for real estate development in Dakar is more profitable than using the same land for farming. In peri-urban areas where agriculture is still dominant, for example Mbao, Keur Massar, Tivaouane Peul, Rufisque and Sangalkam, a plot of land measuring 150 m^2 was, prior to 2000, valued at between FCFA 200 000 and 300 000. By 2011, the same sized plot of land sold for between FCFA 4 and 8 million. The cost of the plot is thus no longer remotely associated with its value for peri-urban agricultural production.

FIGURE 6.3
Heavy developed land in the Yeumbeul suburb of Dakar
Source Mbow et al., 2008

Competing demands for land between agricultural and non-agricultural use affects all types of land, such that even swampy areas are under development pressures, and good agricultural lands are being confiscated for development of the Technopole and road infrastructure such as the toll-road between Dakar and Diamniadio. These areas are highly sought after by real estate developers. Presently, only a part of the humid depressions of the *Niayes* inside the city of Dakar are not threatened with conversion away from its current use for urban agriculture. This situation, in which land usage for peri-urban agriculture is losing ground to real estate development, is an outcome of ambiguous land and urban planning policies on the part of authorities, a disregard for rules, particularly town planning codes, and the uneasy cohabitation between customary law and constitutional law.

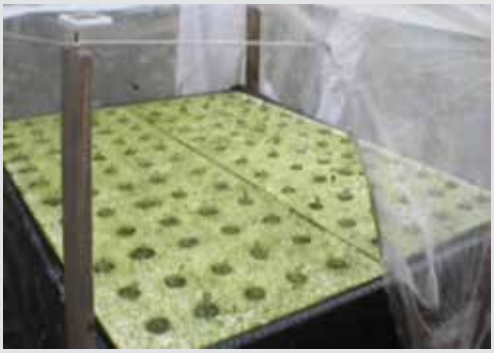
In the near-term, the high value of land can be beneficial to farmers who are users of peri-urban agricultural space. For them, it is a source of revenue for financing farming activities or building a house. Additionally, selling land (or rights to land) provides a means of saving towards retirement. Our investigations reveal that market gardens are operated according to three different modes of valorisation by which land owners manage their land: legal and customary (39.6 per cent), beneficiaries of a simple loan for use of land (50 per cent) or tenants (6.3 per cent). Senegalese land laws are complex, and thus people who use land for agricultural purposes proceed according to the accepted traditional dictum that "Land belongs to the tiller." However, farmers can only be landholders and not landowners, a situation, that, for them, constitutes a major obstacle in terms of accessing funding and insurance given that farmers cannot present land as collateral. Clearly, this situation requires urgent reform of the land-tenure system.

Box 3. Responses to land pressures—new opportunities for UPA

Floriculture is increasingly gaining ground in urban and peri-urban Dakar. Since producers often do not have access to land, they squat on lands adjacent to major roads and in residential quarters. Floriculture is an important informal activity occurring in unclaimed areas with thick vegetative cover, which contrast sharply with the relative desert landscape of urban Dakar. These sites are better maintained compared to public green spaces that the municipal authorities struggle to keep and maintain[4]. To counter risks of flooding, flower producers have developed raised earthen platforms and have resorted to filling soils with gravel in order to improve drainage.

Zones de remblai (floriculture) © 2011 M. Khouma

There is little investment in production given the high insecurity of land holding, and as a result production is suboptimal. Many farmers have no initial training and are mostly farmers who converted to floriculture only after long periods of training in the practice (Fall *et al.*, 2001). Institut Africain de Gestion Urbaine (IAGU) proposes the development of partnership among formal actors (municipalities) and informal actors. In other words, "*instead of ignoring or stigmatising horticulturists, municipal authorities could recognise them as active partners such that they in turn benefit from the complementary contribution of their actions and expertise*"[4].



Micro-gardening in Dakar © 2011 M. Khouma

4 See for example: http://www.iagu.org and http://ateliersyn.wordpress.com/category/interventions-urbaines-urban-actions/

Non-soil micro-market gardening is beginning to emerge in the Dakar area due to the unavailability of land. Practised by women and young people, it consists of growing crops in prefabricated containers (boxes, small wooden tables or basins) covered with a plastic layer and containing macro-enriched water and mineral oligo-elements or an inert solid bedrock composed of gravel, rice balls or groundnut shells (Mandiany, 2002). Micro-gardening practices also include growing vegetables in wooden boxes with liquid nutrients with or without bedrocks. Micro-gardening is a way of popularising gardening in urban households, though it is currently in an experimental phase and there have been no estimates of its potential to address household food needs.

7 The water resource base and UPA

Health risks associated with the use of wastewater

As examined in section 4, food production through urban agriculture plays important economic and poverty reduction roles, and provides a significant contribution to Dakar's food basket. However, the sector faces significant risks associated with access to water, including the myriad environmental and health issues associated with the use of untreated wastewater for irrigation, saltwater intrusion and salinization of groundwater, and the uncontrolled use of chemical fertilizers and pesticides. (Ndiaye *et al.*, 2010; Gaye and Niang, 2002; Cissé 2000). Urban farmers in Dakar (Pikine and Rufisque) rely heavily on urban untreated wastewater (Niang *et al.*, 1999; IAGU, 2001) either as the sole source of irrigation water supply or as backup to compensate for the deficit in céanes water (shallow wells).

Use of untreated wastewater creates an important health risk for both farmers and consumers. A 2009 assessment conducted by the WHO/FAO/CRDI project on "*Integrating and applying WHO standards in the reuse of waste water and excreta in agriculture*, *Dakar, Sénégal*" examined the health

Untreated wastewater used to water garden crops

impacts of polluted water on urban agriculture in Dakar. Their assessment showed that 35 per cent of irrigation water was contaminated with *Salmonella* bacteria. The rate of contamination of the Céanes water (shallow, hand-dug wells) was found to be higher than that of wastewater. Faecal coliform (*Escherichia* coli) was found in the water table underlying irrigated fields and the nearest water points, especially after a rainfall event. A study by Ndiaye *et al.,* (2011) on the microbiological quality of the production chain of lettuce produced by urban agriculture in Dakar found that 35 per cent of irrigation water was contaminated by Salmonella. However, the study revealed no significant difference in the degree of contamination between the two water types (groundwater and wastewater) used for irrigation. Broken wastewater treatment pipes are a significant source of biological contamination of the shallow water table and the Céanes wells at Cambérène in the *Niayes*. In addition to increasing health risks to the population, the wastewater flows into the lowlands, leading to quick and unpredictable eutrophication and invasion by aquatic weeds within a period of several weeks.

An examination of lettuce taken from fields and markets show that *E. coli* content was higher than International Commission on Microbiological Specifications for Foods (ICMSF) standards. The epidemiological study revealed a prevalence rate of 46 per cent of diarrhoea cases in children with a key risk factor being the consumption of underground water (Ndiaye, 2012). Other studies on wastewater contamination in Dakar have as well detected concentrations of faecal coliform and larvae, eggs and cysts from nematodes and protozoa in excess of WHO standards (Faruqui *et al*., 2010).

Euthrophication of Technopole *Niayes* water ©2011 M. Khouma

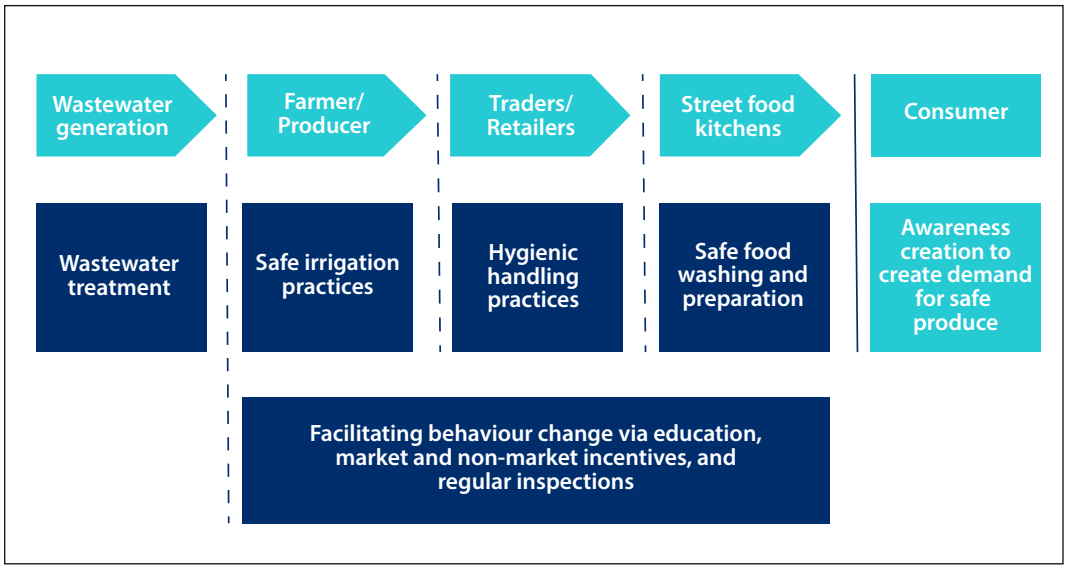


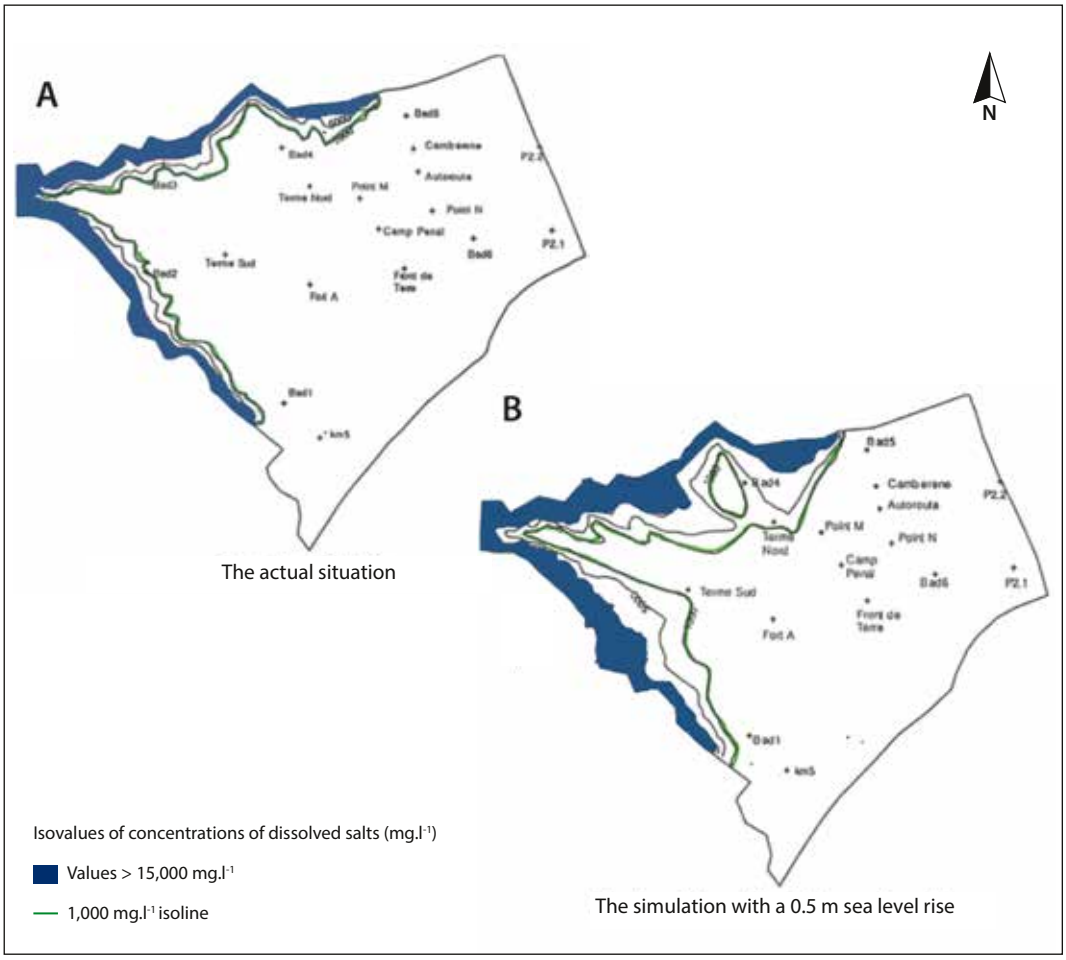
FIGURE 7.1
A multiple-barrier approach to reducing health risks to farmers and consumers from using wastewater in agriculture. This approach, developed by WHO, together with FAO and UNEP, opened the way to targeting a variety of entry points where health risks occur or can best be mitigated before the food is consumed (FAO, 2007).

Direct contact with wastewater is the main route by which farmers are exposed to parasites and pathogens. Manure, frequently used as an organic amendment in cultivating lettuce is another potential source of exposure. Faruqui *et al.*, (2010) estimated that intestinal parasite infection rates of farmers in Dakar ranged between 40 and 60 per cent. The Service National de l'Information Statistique Gaye *et al.*, (2010) estimated that the prevalence rate of intestinal parasitozes was 85 per cent while the national average is 4 per cent. Almost all farmers interviewed for this assessment stated that they used neither gloves, boots nor masks to protect themselves against infection. Therefore, adequate training for farmers, and awareness raising among marketers, street vendors and consumers, would have a positive impact in reducing both exposure and contamination (Figure 7.1). According to Ndiaye *et al.*, (2011) the use of wastewater for irrigation, which is first treated by lagooning—a natural water treatment technique that consists of the accumulation of wastewater in ponds or basins before its use—may be an alternative to groundwater as it would allow reducing the amount of manure used, which seems to be the main source of the microbiological contamination. Consumers of vegetables and fruits produced in the *Niayes* are exposed through consumption of poorly disinfected vegetables, with lettuce and tomatoes being the two most prone to biological contamination. However, many consumers disinfect vegetables or eat only cooked vegetables (Faruqui *et al.*, 2010), thus mitigating health risks.

Threats to water and land resources in Dakar from sea-level rise

Senegal's coastline is highly vulnerable to impacts from sea-level rise associated with climate change (Figure 7.3). The coastal areas of Senegal are expected to be subjected to accelerated coastal erosion, intrusion of seawater into the soils and aquifers of low-lying areas, and inundation of low-lying areas. Analysis by Niang *et al.*, (2010) indicates that the Cap Vert peninsula could face serious consequences by 2050 from a 1 m sea-level rise, with dwellings of 1 to 12 per cent of Cap Vert's population at risk from storm-surge driven inundation. A sea-level rise of only 0.5 m would substantially increase salinization of the aquifers that provide Dakar's drinking water supply (Figure 7.2), which are already contending with significant salinization and nitrate pollution problems. The coastal lakes and agricultural areas of the low-lying *Niayes* are particularly at risk for saltwater intrusion.

FIGURE 7.2
Extent of saltwater intrusion into the Dakar aquifer with a 0.5 m sea-level rise
Source: Niang et al., 2010



The IPCC 4th Assessment Report estimated sea-level rise of between 0.18 and 0.59 m by 2100 (Meehl *et al.,* 2007). However, that may be a conservative estimate because it does not fully account for changes in ice-sheet dynamics (National Research Council, 2010). More recent projections place sea-level rise by 2050 in the range of that estimated by the IPCC to occur at around 2100 (Figure 7.4). These updated estimates are within the range where significant saltwater intrusion into Dakar's groundwater supply could occur, according to the Niang *et al.*, (2010) analysis.

Integrated water and wastewater management

Dakar's water supply is insufficient to meet current demand. Mbaye *et al.,* (1999) estimated a daily shortage of between 100 000 and 162 000m^3 during peak periods. More recent studies are needed to assess the current water deficit. The primary drivers of water deficit are inadequate rainfall to recharge aquifers combined with overexploitation of the water table to meet increased demand from a growing population. High rates of groundwater extraction over the past few decades have been an important factor in increasing saltwater intrusion in coastal aquifers serving urban areas of Africa (Al-Gamal and Dodo, 2009; Kerrou *et al.*, 2010).

Currently, UPA farmers across the *Niayes* are contending with decreasing freshwater quality and quantity, and they are facing uncertainty about future access to water for irrigation. The increasing demand for freshwater for non-agricultural uses combined with the potential for higher irrigation

water demands under warmer and more variable conditions will place greater stress on water supplies and infrastructure that UPA farmers rely on for irrigation. On top of that, increased salinization of groundwater and soils from sea-level rise may further stress the water resource base needed to support the sustainability of Dakar's economically important horticultural sector.

Two preliminary but important responses to the growing threat of diminishing water resources are water conservation and the use of treated wastewater for irrigated agriculture in the *Niayes*. Dakar currently discharges in excess of 100 000 m^3 of nutrient-rich wastewater every day. Mobilizing this resource for use in UPA production could be a viable means to address irrigation needs if measures could be put in place to reduce health risks associated with exposure and contamination from biological pollutants.

The use of wastewater and waste mud drawn from septic tanks or from treatment stations for crop production is a common practice in Dakar. The widespread use of this practice is linked to increasing shortages of freshwater sources, the high cost of fertilizers that make nutrient-rich wastewater an attractive alternative, socio-cultural tolerance for this practice, and the relative difficulty in sensitizing farmers to the risks involved. The availability of nitrogen in wastewater provides an important and, critically, free source of nutrients for vegetable crop farming use in Dakar and is a key to retaining profitability of vegetable farming in the *Niayes* (Faruqui *et al*., 2010).

Addressing the uninhibited use of wastewater would require investments that provide for adequate chemical and mechanical treatment of wastewater to eliminate risks of biological contamination, though this option would entail significant financial costs to create and maintain treatment systems. Simpler and more cost-effective methods have been piloted in the *Niayes,* such as initial treatment with aquatic plants, and use of waste-stabilization ponds that allow for pathogen die-off, which could be considered (Faruqui *et al*., 2007; Redwood, 2004). Integration of some degree of wastewater treatment with irrigation techniques that minimize or avoid contamination is also an important option. For example, promoting the use of *tranchee ristiques* (furrow) irrigation methods that prevent direct contact with crop leaves and developing restrictions on the type of crops irrigated with wastewater (such as to avoid use on lettuce) are important measures, though to be effective they need to be accompanied with strong public awareness and farmer outreach/education efforts (Faruqui *et al*., 2010).

Dilution of wastewater by mixing it with groundwater in certain locations where groundwater has become saline is another option. This practice, which helps to reduce the salinity of water applied for irrigation, has been used for a long time by farmers in the Pikine *Niayes* to water their garden crops.

Reduced loading of contaminated water into the farming environment through water conservation is another important component of a comprehensive strategy on wastewater use. For example, more water efficient technologies such as drip irrigation are gradually being adopted though conventional irrigation still predominates (observation of the assessment team). The largest obstacle to the expansion of drip irrigation methods is its low economic viability linked to the high cost of initial investments. The United Nations Food and Agriculture Organisation (FAO) recently funded the installation of a drip irrigation network to be fed with treated wastewater from an experimental waste treatment unit designed for urban and peri-urban agriculture. Currently, this treated wastewater is being used on trial basis by UPA farmers through the efforts of FAO at Patte d'Oie where a basin has been constructed to link up with the Cambérène purification station. The volume of wastewater treated is a small fraction of the total produced on a daily basis.

FIGURE 7.3
Potential flooding of Dakar with a 1 m (rise in sea level
Source: Wang et al., 2009

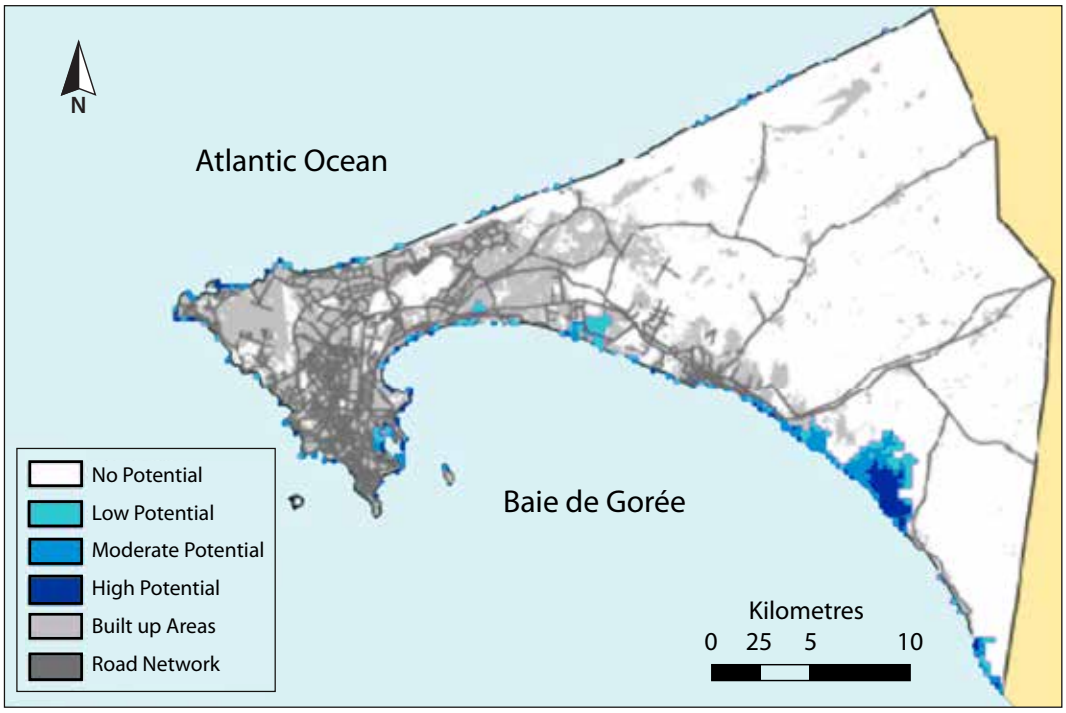
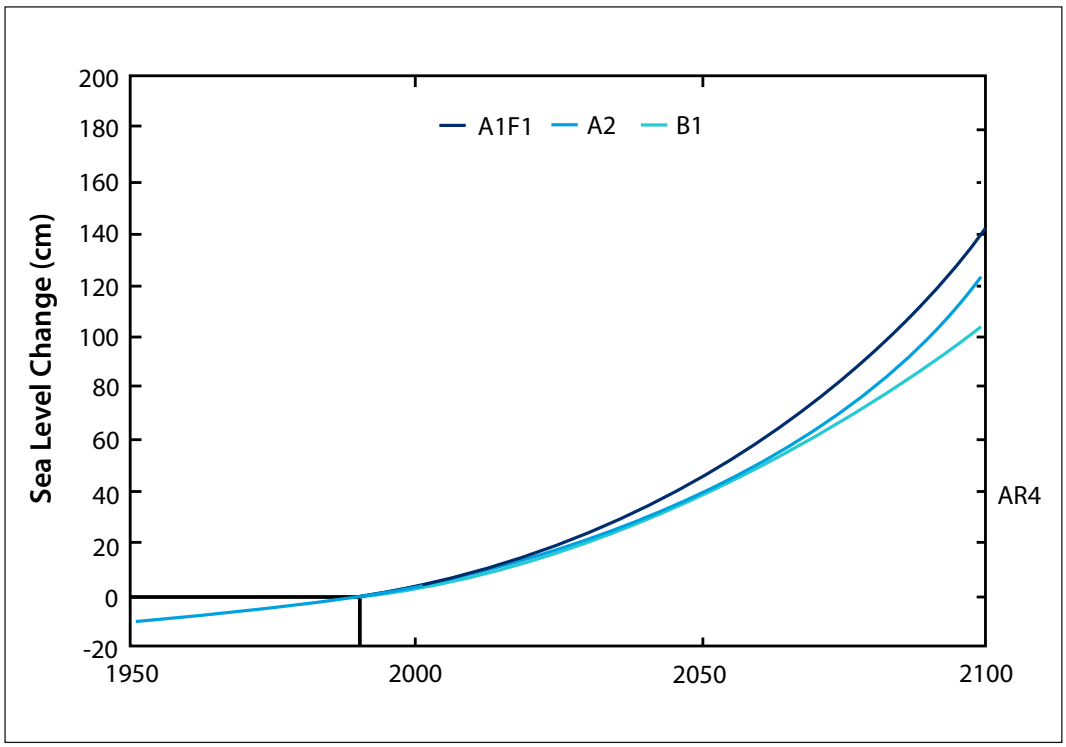


FIGURE 7.4.
Projection of sea level rise from 1990 to 2100
Source: NCR (2010)



Box. 4. Sustainability concerns from Patte d'Oie farmers

The Patte d'Oie site is an area of intense vegetable production in the *Niayes* dating back to the first half of the 20th century. The dominant crop is lettuce, but mint, bell pepper and tomatoes are also grown. Market gardening is practised throughout the year. During the dry season (November to July), production is at its peak and there can even be overproduction. However, profits are higher during the rainy season (July to October) because prices during that season are more competitive. Formerly, market gardening in this area was done only during the dry season, since the farmers were mainly rural migrants who went back home during the rainy season to engage in rain-fed agriculture (millet, maize, groundnuts and cowpea); now, however, the farmers are permanent residents of the area.

Farmers who participated in focus group discussion in conjunction with this assessment noted that the quality of irrigation water remains a major concern. Surface and underground water has become salty, and irrigation done with treated, partially treated or untreated water degrades soil quality. For several years, an FAO pilot programme on water quality provided treated water by the Senegalese National Sanitation Department, but the programme came to a halt earlier this year following an interruption in the deployment of the system. Consequently, the farmers have returned to the use of grey water for irrigation.

The major constraints to agriculture relate to the pressure on land due to increasing urbanization, but also because of the precarious status of the site. Due to new settlements created in the surrounding areas, arable land was greatly reduced in the 1990s. Today, local authorities are still giving out arable lands for settlement purposes. Moreover, rains and floods over the past decade resulted in losses of arable land submerged by runoff water. Even today, some pieces of land are still submerged by water that is itself invaded by plants, particularly *Typhas*. The amount and timing of rain can pose a risk to market gardening activities, though this risk could be abated if excess stagnant water could be evacuated from the site using an appropriate drainage system or otherwise through a water storage system towards water re-use for agriculture.

The *Niayes* of Patte d'Oie has been heavily exposed to strong maritime winds since the surrounding dunes were levelled several decades ago to establish the Parcelles Assainies flats for settlement purposes. According to the farmers, one consequence of heavy winds associated with this land transformation has been the disappearance of several important fruit tree species, including palm, coconut, mango, pawpaw and guava. Today, sapodilla and almond are the only trees that have withstood the physical conditions associated with high winds. The farmers also noted that vegetable production during the rainy season is becoming increasingly difficult because of more extreme heat conditions that adversely affect plant growth, and because of the growing need for more water use, fertilizer and pesticides that reduce profitability.

Agrochemical use in the *Niayes*

Risks linked to improper use of fertilizers and pesticides: The use of fertilizers and pesticides in Dakar's UPA systems creates health risks for both producers and consumers of UPA products. Most pesticides sold in Senegal are generic pesticides, which are cheap and therefore readily accessible to small-scale farmers (Diouf, 2008). They are given exotic local names touting their efficaciousness and power, and are repackaged often without proper labelling. According to Cissé (2000), 122 brands of pesticide are used in the *Niayes*. Pesticides used in Dakar's urban agriculture include *carbofuran, dimethoate, methomyl, ethopropos* and *fenithrotion* have extremely high toxicity and are obsolete in several

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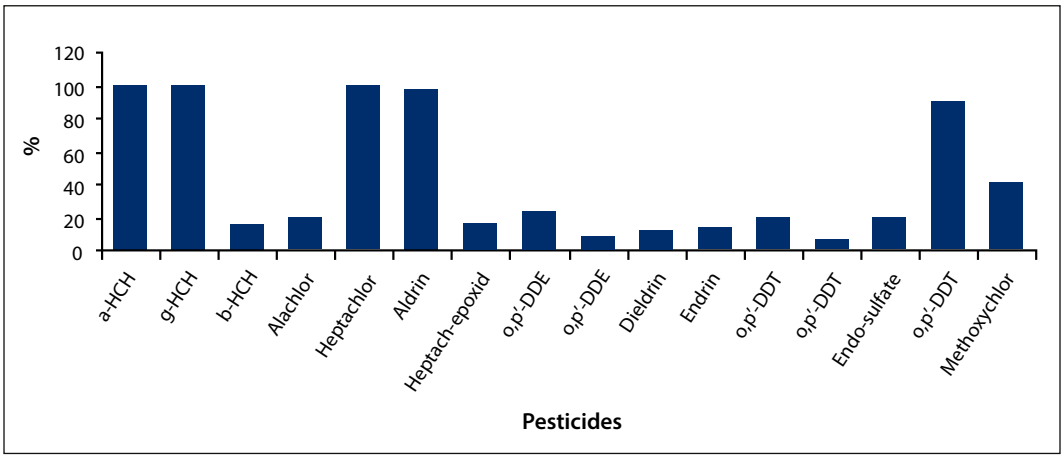
FIGURE 7.5
Types of pesticides used in the area
Source: Cissé et al., 2000



countries. Among these persistent organic pollutants (POP) used are *heptorchlorine, kelthane, califol/ dicofol DD powder (DDT) and dieldrine* (Cissé, 2000). Handling and worker protection measures are either poorly observed or completely ignored by farmers, a situation which exposes them to the risk of poisoning. Badiane (2004) and Chaudhuri (2009) reported, respectively, that 33 per cent and 28 per cent of farmers were victims of pesticide poisoning in 2003 and 2005 in the *Niayes* areas close to Dakar. In addition to insect and disease control, these chemicals are used to combat crop rodents. In focus group discussions held in Patte d'Oie and the Mbao Forest Reserve, farmers noted concerns over the appearance of white fly infestations over the past 10 years, a pest that is difficult to control and that has a low economic damage threshold.

In Dakar, there is a small group of farmers who are trying to promote farming practices that use or require very little chemical input. This form of production is appropriate for export crops such as green beans, tomatoes and strawberries where a strong market for organic products exists. These farmers are increasingly trying to master the entire production/export chain for all products in order to ensure quality.

8 Recommendations

Encourage processes within Dakar that strengthen intra- and cross-sectoral consultations on urban agriculture. UPA clearly makes an important contribution to Dakar's food basket, and the diversity of groups with a stake in the sustainability of UPA is quite broad. They encompass farmers, migratory agricultural workers and others who derive livelihoods from the UPA system, consumers, city planners and governmental officials, and city-based experts involved in environmental sustainability, human health and climate change issues. However, despite UPA's importance to Dakar, there are currently no formal consultation mechanisms in place to allow for collaboration and experience sharing. Initiating a consultative process among researchers, policy makers, urban environment professionals, urban planning professionals, farmers and water and sanitation professionals would contribute to a better organisation of UPA activities and strengthen advocacy for urban agriculture. This framework ought to bring together the diverse stakeholders in urban agriculture and should encourage cross-sectoral coordination on critical issues, such as those at the nexus of food production, environmental protection and human health. Designing a strategic plan to guide the activities to be undertaken along with clear roles and responsibilities of each member must form an important element of this proposed framework. Such efforts would also serve to showcase urban agriculture through current development policies centered on food security, job creation and adaptation to climate change. The recommendation for a more vigorous consultative process is fundamental to the other recommendations in this report.

Strengthen the position of UPA in urban planning. An important goal of the aforementioned consultative process would be to establish and regularize formal communication processes that help policy makers and local authorities recognise UPA as a factor for development. Arable land in the *Niayes* is being squeezed by urban encroachment and will face even more critical challenges in the decades ahead with impacts from sea-level rise and increasing flood risks, which should make maintaining permeable surfaces in the *Niayes*, such as through agriculture and conservation set-asides, a key priority for climate change adaptation in Dakar. Senegal has a policy framework for protecting the *Niayes* in the Dakar Region (PASDUNE) and other policy mechanisms that are conducive to the mainstreaming of urban agriculture in urban planning master plans that could help to meet policy goals related to urban agriculture. However, a lack of clear delimitation of functions and responsibilities between national government and local government authorities has resulted in poor enforcement of land-use planning regulations, which combined with a sharply increasing value of land for real estate development, has served to further marginalize agriculture in peri-urban areas.

There is a strong need for diverse stakeholders to come together and lobby ministers responsible for urban development and national planning, as well as local authorities, towards the formulation of appropriate policies and policy enforcement mechanisms for the protection of agricultural zones and the strengthening of the position of UPA in urban planning by giving priority to land-tenure security for UPA practitioners, and formal recognition of floriculture and other horticulture farming that takes place on public spaces.

Enhance access to safe irrigation water. Inadequate availability of safe water for UPA production threatens the long-term sustainability of the sector in the Dakar region. Current practices involving irrigation with untreated wastewater combined with the increasing degradation of groundwater from saline intrusion and nitrate pollution has created a wholly unsustainable situation from agronomic, environmental and human health perspectives. Continued rapid urban growth combined with adverse impacts from climate change on the water resource base, particularly saline intrusion of groundwater, require novel solutions to addressing water needs for UPA in the *Niayes*. In order to address threats to the long-term sustainability of water resources, the State, local authorities, researchers, civil society, and farmers should work towards developing a comprehensive strategy for minimising human health and environmental risks associated with pesticide use, wastewater irrigation and saline water intrusion.

Potential entry points for enacting such a strategy include training and awareness raising on safe handling and use of pesticides and wastewater irrigation, biological and/or mechanical treatment of wastewater to reduce harmful pathogens, training and financing programs that promote uptake of drip/micro irrigation practices, and the development of an applied research program for understanding the potential for producing horticultural crops under increasingly warm and saline conditions. One way to address water availability would be to develop partnerships between water supply companies and producer organisations for the establishment of preferential tariffs. The State could sponsor these negotiations and even give subsidies for water access in accordance with modalities that are developed. Also, considering the important relationship between lake and wetland areas in peri-urban zones and adjacent farming activities, the management of wetlands should be the focus of applied research.

Strengthen the supply of fresh produce to urban households. Urban food supply chains could become increasingly vulnerable to disruption from extreme climatic events that damage food delivery and storage infrastructure, and from higher temperatures that accelerate spoilage of perishable foods. Under these conditions, reducing the distance travelled between points of food production and consumption, and strengthening food storage facilities to reduce post-harvest loss will become increasingly critical. Both producers and consumers of UPA products in Dakar would benefit from engagement between producer organisations, civil society, the Chamber of Commerce, and city government to identify approaches and investments for achieving efficient storage and distribution that enable consumers to access food of high nutritional value. One important entry point would be to create or strengthen effective organisations to market products from urban agriculture both in the wholesale and in the retail markets. This would require among other things that the wholesale redistribution platforms in Dakar be revitalised and credit unions provide incentives for enhancing investment capacities of producers, wholesalers and retailers. Regular opportunities to discuss marketing problems can lead to shared solutions and action plans aimed at concrete objectives, such as reducing seasonal losses.

Develop and promote appropriate financing mechanisms for urban agricultural producers. UPA stakeholders face significant difficulties in accessing credit due to lack of confidence on the part of financial institutions. It is important therefore to find alternative mechanisms to finance urban and peri-urban agricultural activities that will strengthen the capacity of farmers to innovate and diversify in order to better manage risks and adapt to a changing environment. Promoting dialogue between farmers, policy makers, and financial institutions is a critical first step, particularly if it encourages the design of financial products that are specific to urban agriculture and require the involvement of several stakeholders in accordance with their institutional prerogatives. With regard to such financial products, the Municipal office could contribute to the protection of production areas, at least for the loan period, while the agriculture department could commit itself to providing

technical support service in order to minimise the risk of losses arising from improper cultural practices. In brief, this involves designing a financial product and specifying the involvement of various stakeholders with the view to minimising investment risks. Building financial capital of input distributors and waste recyclers, and of women who buy products from farmers and resell them to consumers is also important.

Better document the contribution that UPA plays in urban food security and poverty alleviation. While it has been widely reported that UPA fosters poverty alleviation and increases food and nutritional security in cities where UPA is actively practiced, there is little quantitative evidence to back this up, and those studies that do exist are outdated. In Dakar, market statistics do not always adequately determine the quantity of products grown and sold in Dakar. Nor is the nutritional quality of vegetables produced by hydroponic micro-gardening and other methods being analysed to verify their nutritional content, nor the level of pathogen and parasite contamination of fresh vegetables. Similarly, in-depth studies are needed to determine the economic impact that direct or indirect UPA employment has on gender-based livelihoods, and household food security and purchasing power. Such knowledge would help to better understand the nexus between UPA, household food security and poverty alleviation. Research institutions and Ministries of Agriculture and Finance need to be able to evaluate, in economic, financial and social terms, the role of UPA, in order to support its achievements and help it better face its present and future challenges. Such efforts could also be used to strengthen the capacity of peri-urban farmers with the view to enhancing their market competitiveness through value addition. Stronger entrepreneurial capacity of producers would help to increase their income and in turn enhance the contribution of urban agriculture to the economy. This would thus contribute favourably to the acceptance of urban agriculture as a development strategy.

Encourage research and communication related to climate change risks. UPA, as with agriculture more broadly, faces a multitude of potential impacts directly and indirectly associated with climate change. Research on climate change and urban food production systems lags considerably behind research on staple crops and extensive livestock systems in rural areas. Among the issues for which virtually no research has been conducted are:

- heat and water stress on horticultural crops and urban livestock keeping under climate change scenarios;
- how expected increases in temperature and humidity and changes in rainfall patterns due to climate change could influence existing or emerging pests and diseases of urban crops and livestock;
- potential interactions that affect horticultural crops, such as between high temperature and high salinity stress; and
- risks associated with using untreated wastewater for irrigation under warmer temperatures and more variable rainfall, in terms of activity of human pathogens and parasites.

Transdisciplinary efforts that involve researchers, farmers, Ministries of Agriculture, Scientific Research, etc., can help to identify action-research themes for UPA related to new technologies, practices and approaches to address climate change adaptation needs.

Promote curricula development at primary and secondary school levels. Curricula development would provide opportunities to improve knowledge of urban agriculture. Such curricula could help to promote:

- Advocacy for the mainstreaming of nutrition curriculum into basic education at the primary and secondary level.
- The promotion in the community of household food security and the production of local foods that are rich in micronutrients.
- The promotion of food norms and standards as well as water and food hygiene measures.
- The establishment of centres to provide training on urban and peri-urban farming practice and techniques.
- The introduction of nutrition education in schools complemented by model school gardens for practical work. School gardens and farms could be linked to initiatives aimed at encouraging students to cultivate gardens at home and to practice small-scale animal rearing.
- Training of farmers and participatory experimentation of agro-ecological farming practices: diversification of crops, organic fertilizers, disease and rodent control, support for productive projects driven by farmers and farmer organisations, improving irrigation systems, better access to seed and tools, marketing organisation, and training and employment of the youth in agriculture.

The Ministry of Education would be well positioned to facilitate the integration of UPA modules in academic curricula. In that way, it could develop in relation with the Agriculture Ministry the field schools approach to promote agro-ecological production.

Strengthen information systems pertaining to the dynamics UPA in Dakar. All the above-mentioned actions must be based on comprehensive observations of the phenomena associated with urban agriculture, which serves the information and knowledge needs of farmers and related private sector enterprises as well as the policy community. The most effective dialogue between these various stakeholders is one in which the players have a basis for reliable evaluation of their situation in terms of resource access and conservation, human health risks, and competitiveness of the sector. Data on agriculture in and around cities are still fragmented from a geographical perspective, do not represent a continuous timeline, are not always sufficiently rigorous and are

not easily available to private stakeholders and policy makers. Urban agriculture is a sector that involves substantial transfers of resources (e.g., land, waste and water) and traded products, and movements of farmers and can, depending on methods and factors of production, either support or undermine environmental quality. The produce in question is subject to numerous hazards and is highly dependent on market demand. Therefore, it is important to have tools for measuring and observing movements of resources and products over time and to effectively assess the changing nature of risks and hazards as well as opportunities associated with UPA.

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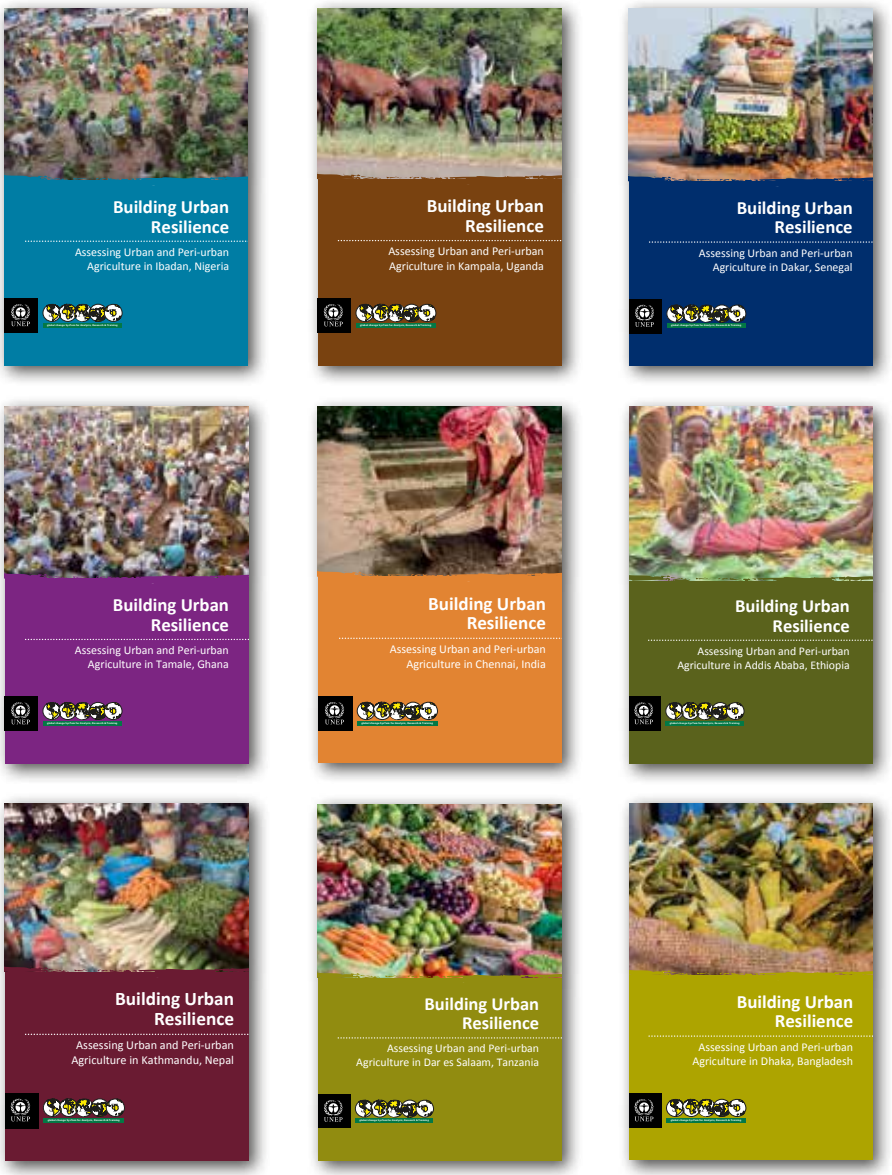
This report represents one from a series of nine city-level reports on urban and peri-urban agriculture (UPA), which together form a larger knowledge assessment. The knowledge assessment was carried out in Dakar (Senegal), Tamale (Ghana), Ibadan (Nigeria), Dar es Salaam (Tanzania), Kampala (Uganda), Addis Ababa (Ethiopia), Dhaka (Bangladesh), Kathmandu (Nepal) and Chennai (India). The nine reports and a synthesis report can be downloaded at: http://start.org/programs/upa



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